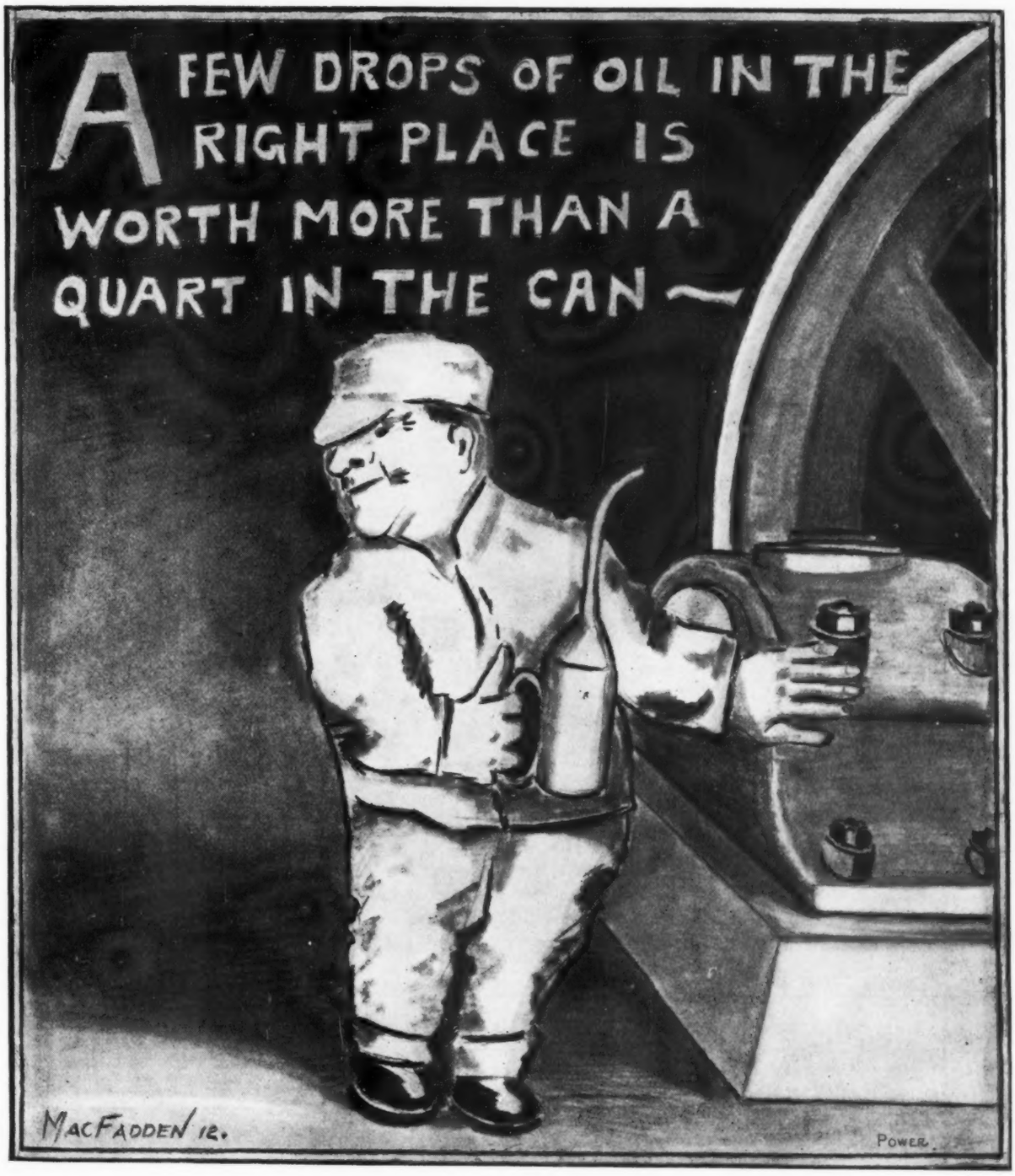
POWER

Vol. 37 NEW YORK, FEBRUARY 4, 1913 No. 5



Plant of Packard Motor Car Co.

By A. R. Maujer

SYNOPSIS—Outline of the rapid growth of a direct-current plant which in 1903 was of only 350 hp. capacity and today has 8000 hp. capacity in electric-generating equipment alone. The 3000-hp. main units, at the time of their installation, were the largest ever installed for 240-volt service.

Designing any power plant usually involves certain problems peculiar to it alone in addition to the general problems common to all. In the Packard Motor Company's plant in Detroit the special problems were caused by the rate at which the demands upon it have increased. The automobile industry is an unusual one because of its unprecedentedly rapid growth. The Packard works represent no small part of that growth and every second year thus far has seen an increase in the capacity of the present power plant equivalent to 200 per cent. of that of the original installation.

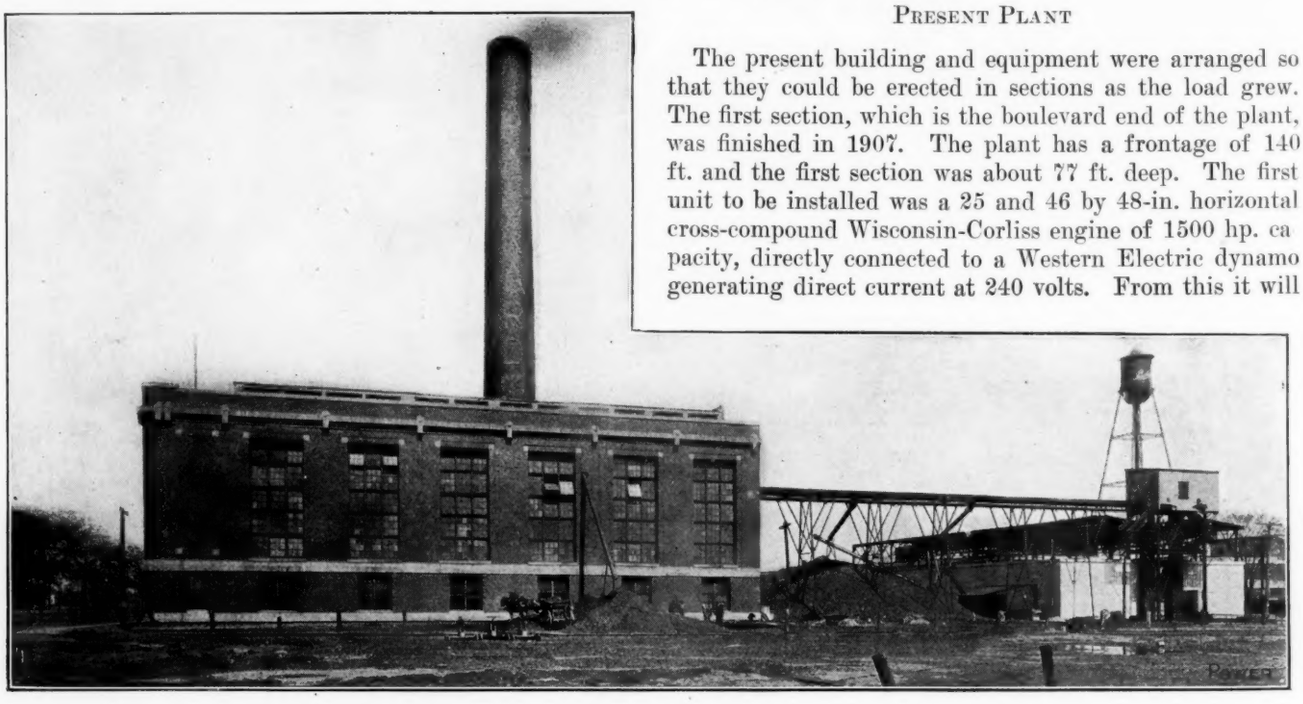


Fig. 1. New Plant of the Packard Motor Car Co., at Detroit, Mich.

The Packard works are on the outskirts of the city, on East Grand Boulevard, a wide, well made and much used thoroughfare. The executive offices front on one side of the boulevard and the power plant stands just opposite. Because of the conspicuous location of the plant special attention was paid to the external finish of the building; the walls are faced with selected hard-burned red brick and trimmed with granite. A side view of the plant is given in Fig. 1.

Original Plant

The original plant, built and put into operation in 1903, was modest enough, having an engine room but 50 ft. square, which contained one 350-hp. tandem-compound Ball high-speed engine driving a direct-current dynamo. Two McNaul 200-hp. water-tube boilers equipped with Detroit automatic stokers supplied the steam. The plant also contained one Blake & Knowles underwriters pump of 1000 gal. per minute capacity and one 6x4x6-in. Laidlaw-Dunn-Gordon duplex boiler-feed pump.

In the following year another 200-hp. McNaul boiler, another 250-hp. Ball engine and a Franklin air compressor of 350 cu.ft. per min. capacity were added to the equipment.

A year later, in 1905, a 500-hp. Ball engine was installed together with another boiler, another feed pump and an air compressor of 100 cu.ft. per min. capacity. By this time the full equipment as laid out in the original plans was in operation and there was no satisfactory way in which to increase the capacity of the plant or make an extension. Consequently, to provide for the rapidly occurring increases in the power requirements, an entirely new plant was laid out.

Present Plant

The present building and equipment were arranged so that they could be erected in sections as the load grew. The first section, which is the boulevard end of the plant, was finished in 1907. The plant has a frontage of 140 ft. and the first section was about 77 ft. deep. The first unit to be installed was a 25 and 46 by 48-in. horizontal cross-compound Wisconsin-Corliss engine of 1500 hp. capacity, directly connected to a Western Electric dynamo generating direct current at 240 volts. From this it will be seen that the size of the unit had been increased considerably since the first engine in the original plant was installed only four years before. It will be seen further that the size was to be increased still more, for when the second section of the plant was erected in 1908-9, adding 44 ft. to the depth of the building, a 38 and 70 by 54-in. C. & G. Cooper horizontal cross-compound Corliss engine of 3000 hp. capacity, driving another Western Electric 240-volt direct-current dynamo was installed, shown in Fig. 2. At the time this was the largest direct-current unit of that voltage ever installed in the United States.

Direct current was adhered to because it is easier to operate the generators in parallel and variable-speed motor operation was considered more satisfactory with

direct current and direct-current motors are better for machine-tool work. Then, too, the old equipment throughout the plant was arranged for direct current and to

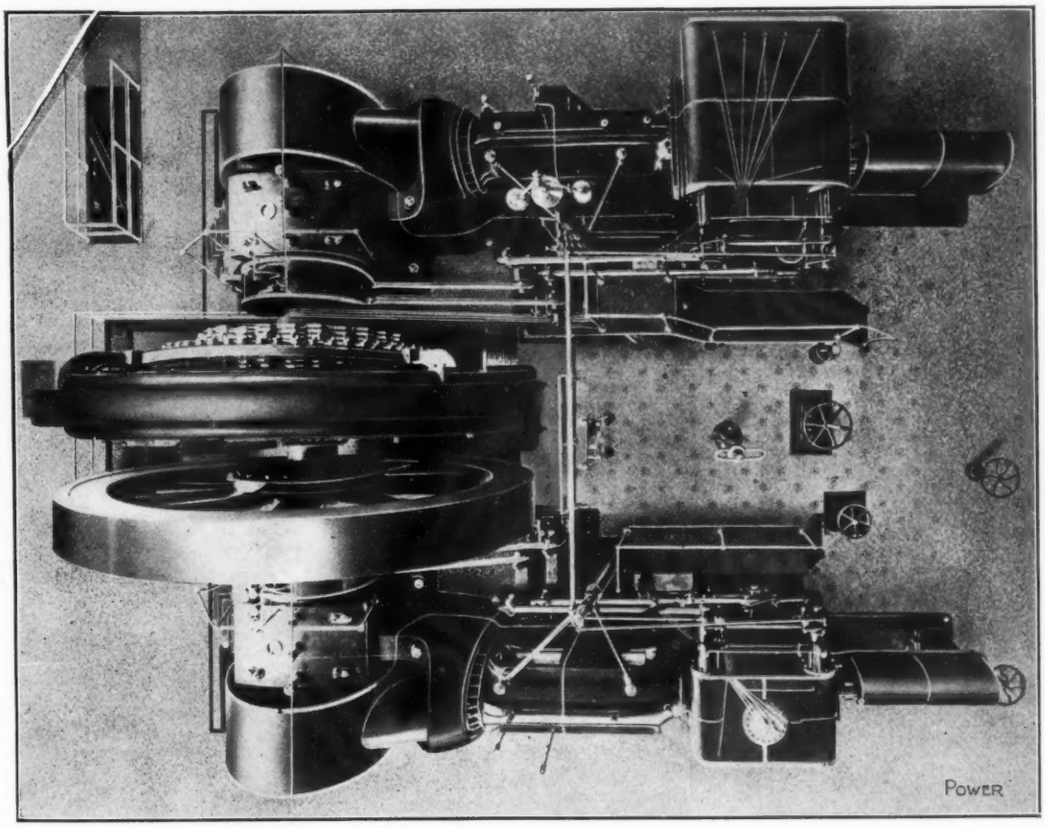


FIG. 2. BIRDSEYE VIEW OF THE COOPER ENGINE

change at this time would have meant complication in system and equipment.

VALVE-GEAR OF 3000-HP. ENGINE

A feature of the Cooper engine is the valve-gear shown in Fig. 3 and known as the Cooper improved gravity latch gear. The points to commend this gear are its noiseless operation, simplicity and accessibility. The latching or hooking-up operation is performed by a pick-up plunger, through the action of gravity. The pick-up plunger guide block has an auxiliary spring attachment which can be brought into use instantly while the engine is in operation to assist the gravity-latching action of the pick-up plunger, if for any reason its gravity-latching action should become sluggish.

The releasing action is transmitted from the governor cam, through the roller arm and lifting bar, to the pick-up plunger. The end of the roller arm which engages the governor cam, is always in rolling contact on the governor-cam ring. The opposite end of the roller arm, where it is joined to the lifting bar, has an adjustment for changing the lap of the steel blocks, if any of the block edges become unduly worn or accidentally broken.

The engaging faces of the steel block on the pick-up plunger and the steel block on the steam crank are parallel, in a radial line extending perpendicularly from the center line of the valve stem. The pick-up plunger maintains this same radial line in all its working positions, due to its fixed path of travel in the pick-up plunger guide block. Therefore, after hooking up, the engaging faces of the steel blocks continue to remain parallel to each other up to the time release takes place. This parallel sliding motion of the block faces against each other, during their working periods, eliminates a common source of annoyance, viz.: the rounding off of the block edges. Owing to the flexibility of the pick-up plunger, its block automatically adjusts itself squarely and evenly against the block on the steam crank, so that the wear on the block faces is uniform.

The governor-cam rings are on the inner side of the bell cranks. This construction serves as an extra precau-

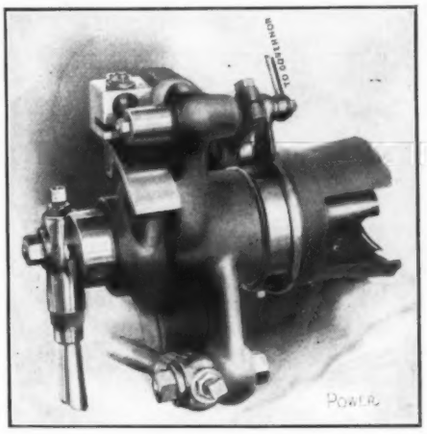


FIG. 3. DETAIL OF THE COOPER ENGINE VALVE-GEAR

tion to protect these important parts from accidental injury.

The safety and knock-off cams are combined in one

large cam. The governor-cam ring is formed to receive this combined cam in a recessed joint and in addition, a locknut is used to lock the cam securely in place. The object of combining these two cams in one larger cam, is to provide for absolute equalization of the cutoff in each end of the cylinder. This is brought about in the final setting of the valves, when it is only necessary to shift the combined cam, until equal points of cutoff are obtained. After this final adjustment has been made, equal points of cutoff will be maintained under all conditions of operation, from no load to full load. This adjustment feature effects a marked improvement in regulation and economy, when the engine is operating under variable load conditions.

The vacuum pots are of the piston type, sealed with oil grooves. If for any reason they should fail to act, the steam crank is automatically closed by the mechanical engagement of the bell crank against it.

Second 3000-hp. Unit

In 1910 the building was extended 44 ft. farther and a second 3000-hp. Cooper engine, a duplicate of the first, was installed to drive a General Electric direct-current dynamo.

Fig. 4 is from a recent photograph of the engine room, giving a view from the boulevard entrance. The 1500-hp. Wisconsin-Corliss engine stands at the extreme left and out of the field of vision. Next to it is the 3000-cu.ft. compressor, one air cylinder of which can be discerned at the left of the illustration. To the right are the two 3000-hp. Cooper engines. The wall, seen at the end, is a temporary one of wood, waterproofed on the outside. It has done duty for each successive section of the plant thus far, but when the fourth and final section is constructed it will be discarded for a permanent wall in keeping with the rest of the building. And it might be stated in passing that the rest of the building is particularly well finished and well kept. As the chief engineer, Fred Willins, expressed it: "We are proud of the plant, take good care of it, and respect it in every way as the heart of a big institution should be respected." The floor is finished in white tile set off with an artistic design and border of colored tile and a high wainscot around the walls is finished in white-enamel brick, as also are the pedestals of the various machines. Large windows in the front and side walls admit plenty of light and insure good ventilation.

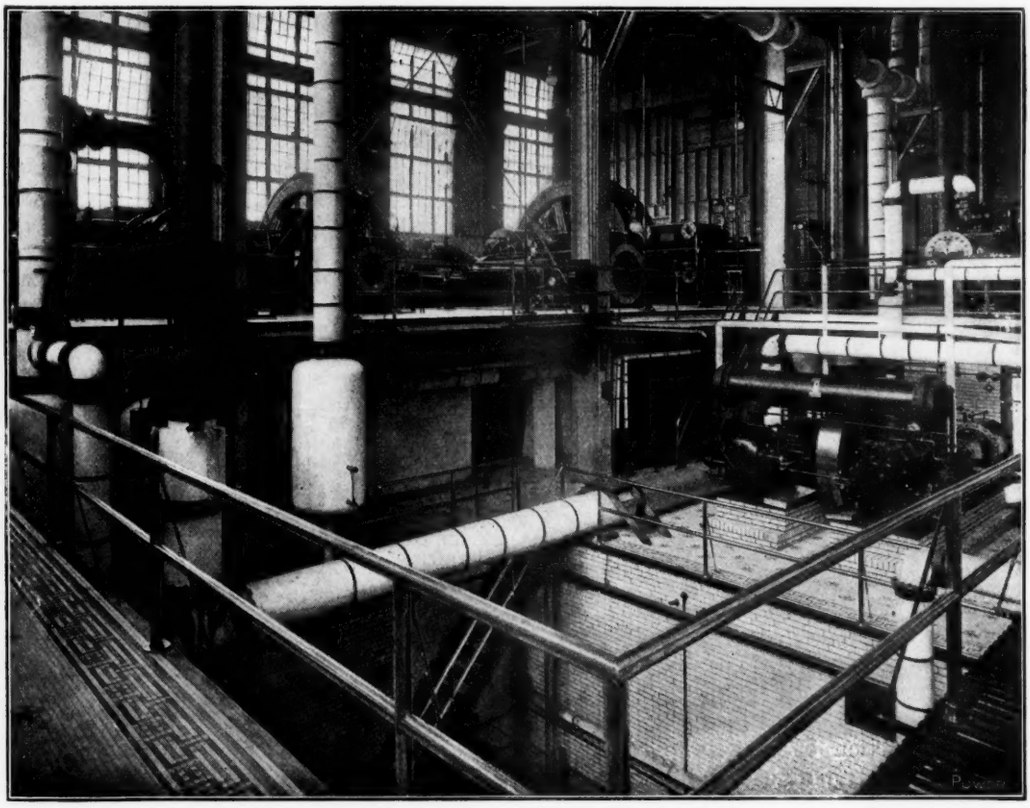


Fig. 4. View in the Engine Room of the Packard Plant

In 1909 an Ingersoll-Rand two-stage air compressor tandem connected to a Hooven-Owens-Rentschler horizontal cross-compound Corliss engine 20x32x42 in. in size was also installed. This unit will compress 3000 cu.ft. of air per min. to 80 lb. pressure when operating at 85 r.p.m. The air cylinders are 19¼ and 32¼ in. in diameter, respectively.

In this same year the original plant, which had been kept in service until the new plant was far enough completed to take over the entire load, was dismantled. Two of the boilers from this plant and the two 250-hp. Ball engines, together with the necessary piping, the stokers, feed-pump and feed-water heater, were shipped to New York City and installed in the Packard service plant at Astoria, Long Island.

A steel and glass partition divides the boiler and engine rooms so that, although no light is cut off from either during any part of the day, no dust or dirt stirred up in the former can invade the latter. Originally numerous inclosed arc lamps, hung from ornamental brackets from

the building columns or supported on special poles, provided the general illumination at night, while clusters of incandescent lamps furnished light where concentration was required. Recently, however, the arc lamps

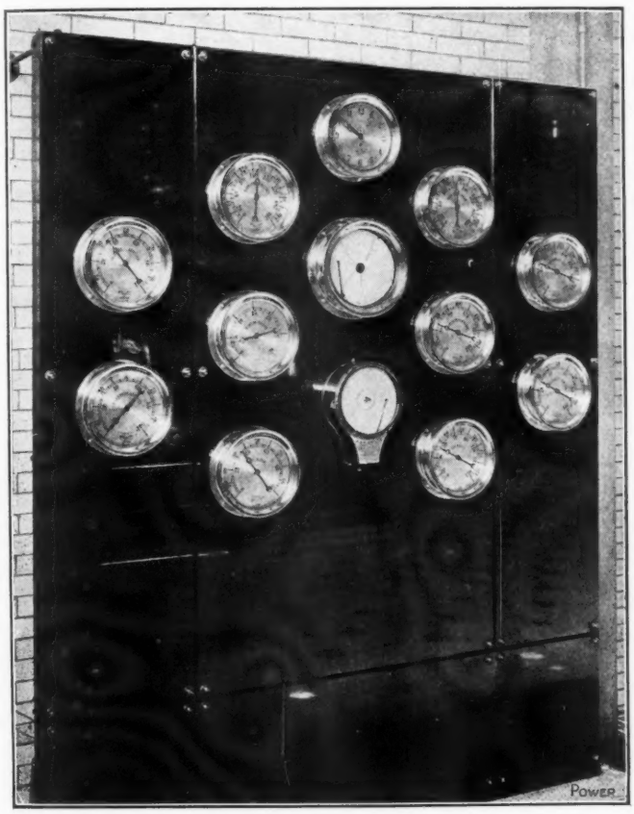


FIG. 5. THE CENTRAL GAGE BOARD

have been supplanted by Cooper-Hewitt mercury-vapor lamps.

PUMPS

Referring to Fig. 4, the pit in the foreground contains the three boiler-feed pumps, the pumps for the heating returns and for the hot-water service throughout the building. The feed pumps are a Worthington outside center-packed horizontal duplex, 17x10x15 in. in size, and two Fairbanks-Morse 18x12x18-in. pumps of the same type. The feed-water main, 8 in. in diameter, is in duplicate; one main feeds into the upper drums of the boilers and one into the lower.

The hot-water supply for the various buildings is handled by either of two Blake-Knowles duplex 7½x5x6-in. pumps. The suction connects with the feed-water heater, and the discharge with the 4-in. supply main which serves all of the various buildings. A 1½-in. return pipe also connects with the heater so that the water may be circulated and a constant supply of uniformly hot water is therefore instantly available at all points.

The returns from the heating system flow back by gravity to a return tank in the pump pit from which they are lifted to the heater 30 ft. above by either a Marsh 12x18x12-in. outside center-packed duplex pump or a Weinman Machine Co. pump of the same time and size. The feed-water heater is on the engine-room side of the partition close to the pump pit. It is a Cochrane; when it was installed at the time the present plant was erected its capacity was 3000 hp.; this was increased later to 5000 by raising the top section and inserting an additional section.

The air compressor on the basement floor, as shown in Fig. 4, is the one of 1000 cu.ft. capacity taken from the old power plant when the latter was dismantled, and is installed in the new plant for emergency use. The engine, which may be seen just above it on the main floor, is the 500-hp. Ball engine, also taken from the old plant and employed in the new one for carrying the light and power load during the noon hour and at other times when the requirements are especially small.

GAGE BOARD AND SWITCHBOARD ARRANGEMENTS

Conveniently near the chief engineer's office is the central gage board, shown in Fig. 5, the equipment of which is unusually complete. The following pressures are shown: main steam header, fire-pump steam main, various engine receivers, compressed air, heating system, fire-pump discharge, intercooler and receiver of air compressor, city water and hot-water supply pressure. In addition, the board carries a recording voltmeter and a recording wattmeter.

Perhaps the feature that strikes a visitor to this plant the most forcibly is the absence of a general switchboard. Just back of each generator is a single panel on which are mounted the main switch, the circuit-breakers, the rheostat handles, and the ammeter and voltmeter for that particular unit. As for the feeder switches, instruments, etc., there are none, nor are any strictly necessary.

BOILER ROOM

In the boiler room, Fig. 6, are 11 Wickes vertical water-tube boilers, each of 400 hp. rated capacity, equipped with

FIG. 6. VIEW IN THE BOILER ROOM

standard Murphy automatic smokeless furnaces. The steam pressure is carried at 150 lb. gage. An underground brick-lined flue connects the boilers with a radial-brick chimney 175 ft. high and 12 ft. in inside diameter. Coal

is fed to the furnaces by gravity from an overhead suspended type of sheet-iron bunker. The ashes drop through a hopper in the bottom of the ashpit into wheelbarrows in which they are carried to a bucket-elevator conveyor which lifts them to such a height that they may be discharged through a chute into cars on the railroad siding which lies alongside the boiler house.

A Sarco and a Precision Instrument Co. automatic flue-gas machine are so arranged that samples of the gas may be drawn from the chimney, the flue or from any boiler.

Coal Storage and Handling

The coal is stored in a concrete bin, as shown in Fig. 1. This bin is 140 ft. long by 74 ft. wide and is 20 ft. high from the ground line. Its capacity when filled by the coal-handling apparatus alone is 4000 tons and when trimmed by hand, 5000 tons. The coal is delivered in hopper-bottom cars on the siding alongside of the bin. From these it is dumped into a receiving hopper between the rails and fed to a conveyor which carries it to the crushers which are in the same pit as the receiving hopper. A bucket elevator raises the crushed coal to the overhead conveyor level. If the coal is required for immediate use it is fed to the conveyor, which may be seen extending into the boiler house in Fig. 1. This is a screw conveyor; a long spiral blade fitted into a trough forces the coal along until the outlets at various points in the overhead boiler-room bunker are reached. This bunker is 154 ft. long and has a capacity of seven tons per lineal foot. If the coal is to be stored, it is fed to two overhead bin conveyors, also of the screw type, and distributed evenly in the storage bin. A brick arch tunnel along the center of the bottom of the bin contains a conveyor which delivers the coal to the bucket elevator. This in turn delivers it to the boiler-house conveyor. Fig. 7, which is a view of the bin before it was completed, shows the return-conveyor tunnel with the openings in its side for receiving the coal.

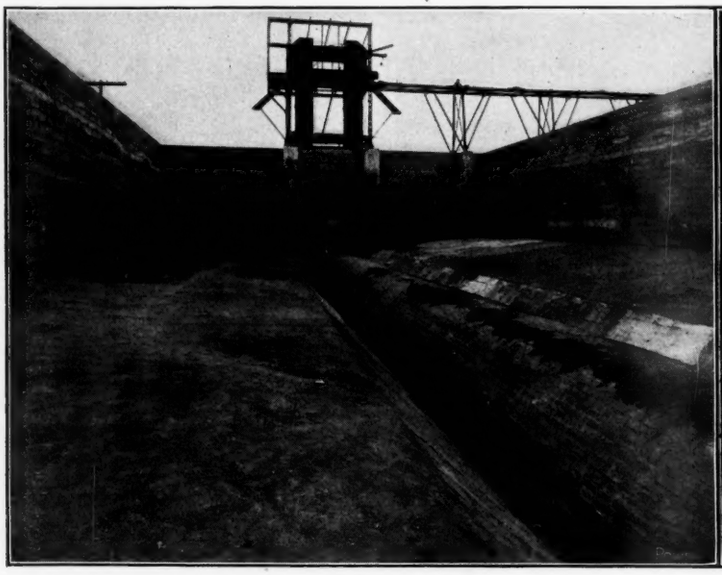


Fig. 7. The Concrete Coal Bin before Completion

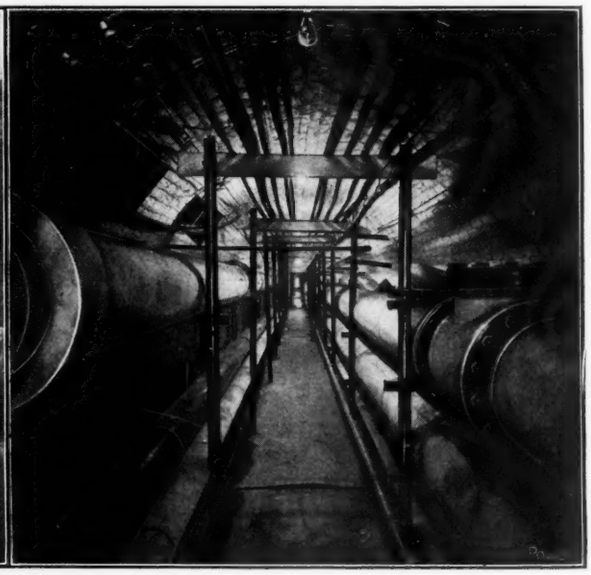


Fig. 8. View on One of the Pipe and Wiring Tunnels

Piping

A main header, 16 in. in diameter, runs the length of the first and second sections of the engine room, supported on brackets on the building columns about 26 ft. above the floor level. The 8-in. main leads from the boilers come through the partition about 14 ft. higher up and drop down to the header with long-radius bends. The leads to the main engines drop straight down to a steam separator just below the engine-room floor level and then extend across under the floor to the engine.

The main header for the third and fourth sections, also 16 in. in diameter, lies along the basement floor. The leads from the boilers are brought over in a semicircle 16 ft. 6 in. in diameter and make a vertical drop of 39 ft. to the header. The lead to each engine extends under the engine-room floor to a steam separator near the engine from which connection is made direct to the throttle. The two sections of the main header are connected with a 12-in. line controlled by a gate valve so that they may be isolated at will. Extra-heavy pipe with Van Stone joints is employed throughout.

An auxiliary header 10 in. in diameter and fed by separate 4½-in. leads from the boilers runs the entire length of the plant on the engine-room side of the partition supported on brackets 27 ft. above the engine-room floor line. In addition to supplying all the auxiliaries, this header furnishes all the high-pressure steam required throughout the works.

A second auxiliary header, 8 in. in diameter, connects with the two fire pumps and the fire whistle only. These pumps are a Blake-Knowles underwriters of 1000 gal. per min. capacity and a Fairbanks-Morse underwriters of 1500 gal. capacity. They are in the basement on the east side of the plant. A cross-connection between this fire-pump header and the 10-in. header allows connecting the two together if necessary.

The exhaust from the main units is collected in one main exhaust header, which varies in size from 18 to 26 in. From this two 16-in. leads are taken off for the heating system and run through the two main tunnels. A 10-in. connection supplies the feed-water heater. The exhaust from the auxiliaries is received by an 8-in. header which connects directly with the heater.

A 6-in. connection between the 10-in. auxiliary steam

header and the exhaust-steam heating main supplies live steam through a pressure-reducing valve whenever there is a deficiency of exhaust steam.

Tunnels

Tunnels are employed for distributing electricity, compressed air, hot and cold water, high-pressure steam and exhaust steam to the 27 buildings throughout the works, the combined floor space of which amounts to over 37 acres. One main tunnel, Fig. 8, runs directly north 1500 ft. It is built of brick and is 8 ft. wide by 8 ft. high.

When passing under the public street the tunnel is 12 ft. below grade, as required by law; on Packard property it rises to 1 ft. below. Another main tunnel of the same size and construction runs south 1100 ft. Smaller branch tunnels extend out from the main ones to serve those buildings which are not in direct line. Branch lines from the various air, steam and water mains extend into each building and a main electric feeder or a tap extends to a distributing panel in the basement.

Auxiliary Boiler Plants

In the drop-forge department, which is remote from the power plant, there are two 400-hp. Wickes vertical boilers equipped with Murphy furnaces and a Cochrane heater. These supply steam at 140 lb. pressure for the steam hammers; the exhaust is used for heating the forge and foundry buildings.

In a separate house is a 200-hp. McNaul boiler which generates steam at 250 lb. pressure for heating some enameling ovens. This boiler is fired by hand with wood, rags, waste and other combustible refuse from the works.

F. F. Van Tuyl, Detroit, Mich., is the consulting engineer for the Packard company, under whose supervision the plant was designed and erected. We are indebted to him for assistance in preparing the foregoing description.

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Oil Fuel for Destroyers and Battleships*

SYNOPSIS—Advantages and disadvantages of oil as fuel. Its evaporative and thermal value as compared with coal.

❖

In deciding to adopt oil fuel for use on battleships and destroyers, the Navy Department took into account the following advantages which would be gained by its adoption:

1. Less fuel required for any given radius of action, consequently less percentage of displacement and less bunker capacity required for the fuel.
2. Increased boiler efficiencies.
3. Decreased fireroom force.
4. Less deterioration of boilers due to maintenance of more even temperatures.
5. Ability to maintain high powers for indefinite periods.
6. Less deterioration of ship's structure due to there being no water or ashes in the bilges.
7. Greater cleanliness.
8. Greater ease in replenishing fuel supply, both in port and at sea.
9. Less floor space required for the development of a given power.
10. Greater ease in control of steam supply.

In opposition to these undoubted advantages the following disadvantages exist:

1. Fuel oil less widely distributed over the earth than coal.
2. Greater unit cost than coal.
3. Greater danger of fire than with coal.

The reply to the first disadvantage is that in time of war a fleet operating far from a base would depend upon fuel ships for replenishing her bunkers, and that oil can be carried in bulk as well as coal, and bases where stores of oil can be kept on hand are as easily established as are bases for coal, and such oil bases would have, in case of danger of capture by an enemy, the additional advantage of being much more readily destroyed, together with their stores of fuel, than are coal bases.

The second disadvantage, that of excess cost over coal, is more than compensated for by the quoted advantages.

The third disadvantage, that of danger from fire, is very thoroughly guarded against by storing the oil in compartments remote from the boiler rooms, and situated well below the water-line of the vessel. In addition to these primary precautions, additional safeguards are provided which render the danger from fire fully as remote as the danger from magazine explosions.

Upon deciding upon the adoption of oil as a fuel for the naval service, the Bureau of Steam Engineering examined carefully all the systems for burning oil that now exist and finally decided upon that of mechanical atomization of the oil as the one most suitable for naval use. In this system, the oil is pumped through heaters to the burners, within which it is given a whirling motion. The small central core of oil, discharging through the tip orifice with this whirling motion, the oil flies off and forms a cone of fine mist. This oil mist mixes thoroughly in the furnace with air which passes into the furnace through a cone register surrounding the burner, the register having adjustable openings and guide vanes so that the amount of air to each burner may be regulated and the direction of flow of this air be slightly oblique to the axis of the cone of oil.

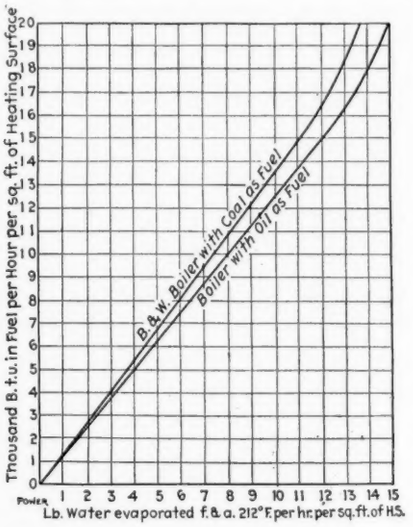
The success of the system depends almost entirely upon the proper handling of the air. Improper air regulation will produce a series of rapid explosions of oil in the furnaces with consequent destruction of the brick linings of the furnaces. With proper handling, the oil burns almost noiselessly, and the amount of smoke produced can be held absolutely under control.

In the first battleships fitted for oil fuel, the oil was only intended as an auxiliary fuel to be used as an aid in keeping up steam when the coal should be so low as to be remote from the firerooms and so require excessive trimming. The results obtained with this mixed system were not good, as the furnace volumes of coal-burning boilers are too small to permit efficient burning of oil. Furthermore, when burning the oil and coal in combination it is impossible to so regulate the air supply that each fuel will obtain the proper amount. This re-

*Excerpt from paper read by Capt. C. W. Dyson, before the Society of Naval Architects and Marine Engineers.

sults in excessive production of smoke and no increase in steam production over coal alone.

To illustrate the value of oil when used as the sole fuel as compared with coal the accompanying chart has been prepared. The two fuels were tried under the same boiler,


Thousand B.t.u. in Fuel per Hour per sq. ft. of Heating Surface
B. & W. Boiler with Coal as Fuel
Boiler with Oil as Fuel
Lb. Water evaporated f. & a. 212° F. per hr. per sq. ft. of H.S.

EVAPORATION WITH COAL AND OIL

the grates being removed after the coal trials and the fronts rearranged to accommodate the burners and air cones.

To compare the relative values from this chart, let a ratio of heating surface to grate surface of 40 to 1 be assumed and a rate combustion of 40 lb. of coal per square foot of grate be taken, the coal having a thermal value of 14,500 B.t.u. per lb. This rate per square foot of grate gives one pound of coal per square foot of heating surface per hour and a supply to the furnace of 14,500 B.t.u. per square foot of heating surface per hour.

From the chart where this value of B.t.u. per hour per unit of heating surface is supplied to the boiler in the form of coal, the consequent evaporation from and at 212 deg. F. per square foot of heating surface will be 10.8 lb. of water. Should this same amount of B.t.u., 14,500, have been introduced into the furnace in the form of oil fuel, the resultant evaporation would have been 11.72 lb. of water.

One pound of oil, however, may be rated at a thermal value of 19,200 B.t.u., therefore the total evaporation per pound of oil would be

$$\frac{19,200}{14,500} \times 11.72 = 15.519 \ lb.$$

against 10.8 lb. per lb. of coal, a ratio of 1.437 : 1, while, if the thermal values of the fuels be compared, the ratio is 1.324 : 1.

The difference between these ratios, in favor of actual evaporative results, is caused by the elimination of all grate losses and losses due to sooting up of heating surfaces when oil is used.

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Feed Water Heating and Pumping*

SYNOPSIS—Types and location of heaters, sources of steam and typical layouts. Single direct-acting feed pumps have become the standard. A comparison in steam consumption and weight of direct-acting and rotary pumps.

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In the last 25 years the development in marine feed-water heating has merely consisted in the adaptation of design to suit the conditions imposed by varying requirements for different classes of vessels. As regards types of feed heater, there are only two, direct contact and surface. There are also two locations, the first being on the suction side and the second on the discharge side of the feed pump. The heating steam may be obtained from two sources, auxiliary-exhaust and receiver steam, and on these six variants many different arrangements have been devised.

Broadly speaking, direct-contact heaters should be, and generally are, of universal adoption, on account of their simplicity and of the outstanding advantage of their ability to eliminate the corrosive gases from the feed water. Their universal adoption is, however, controlled in lighter draft vessels and in warships, by the necessity of placing them high up in the ship, and also to a slight extent by a disinclination to mix auxiliary exhausts direct with the main feed on account of the suspected boiler troubles due to oil. In large ships where the exhaust of single auxiliaries, such as electric-light engines of considerable power, do contain oil in a considerable amount, this argument is tenable, but when it is considered that almost 5000 vessels are now running satisfactorily with direct-contact heaters, many of them 25 years old, and in addition that there are probably more cases of trouble with oil in boilers on vessels without direct-contact heaters, than with them, some other explanation must be looked for in connection with this difficulty.

As regards location, direct-contact heaters are necessarily always on the suction side of the feed pumps, while surface heaters are most frequently arranged on the discharge side, although not necessarily so. A discharge surface feed-water heater offers the only method of obtaining very high degrees of feed heating over, say, 230 deg. F.

As regards the source of heating steam, the essential principle is to use, in the first place, all the auxiliary exhausts and then supplement from the low-pressure receiver. In earlier days the proportion of auxiliary exhausts to the main feed quantity was low, now it has greatly increased. In ordinary cargo steamers these exhausts will, on the average, heat the feed water through a range of about 70 deg. F., and in some passenger steamers through a range of 90 deg., while in turbine vessels, and especially combination vessels, the range is rendered much higher on account of the increased efficiency of the main installation as compared with reciprocating installations, and also by the additional steam required for independent air and very large circulating pumps, together with the provision of oil-lubricating and water-service pumps. These represent increases on the

*From paper read by William Weir before the Institution of Engineers and Shipbuilders in Scotland.

auxiliary exhaust supply, while for the same power the main feed water itself is decreased.

Diagrammatic sketches of two representative systems were shown. The first was specially applicable to vessels fitted with large electric-light installations where the generators are driven by reciprocating engines of which the exhaust steam contains a certain proportion of oil, and where it is not generally advisable to lead the exhausts from such engines into the same exhaust pipe as the other auxiliaries on account of the fluctuations in pressure. "Dual" air pumps deliver to a hotwell tank, from which an independent hotwell pump draws the water and delivers through a low-pressure surface feed heater to a direct-contact heater. The main feed pumps then draw from the direct-contact heater and deliver to the boilers through the main or auxiliary pipes. The supply of heating steam to the surface heater is the exhaust from the high-speed reciprocating engines driving the electric generators, and the condensed drain water from this heater passes through a gravitation filter to the hotwell tank. The heating steam to the direct-contact heater is all auxiliary exhaust steam, with the exception of the exhaust from the generator sets already mentioned.

The second diagram illustrated an arrangement for large vessels where it is desired to separately filter the whole of the condensed auxiliary exhaust steam before mixing it with the main feed supply. The installation consists of two or more pairs of feed pumps, air pumps, with attached hotwell pumps, low-pressure surface feed-water heater and high-pressure feed-water heater. The air pumps discharge into a self-contained hotwell, from which the hotwell pumps draw and deliver through a low-pressure heater to a float tank. The main feed pumps draw from the float tank in which is contained their control gear, and deliver to the boilers through the feed-water heater, or through the auxiliary feed pipe.

In this arrangement the electric-engine exhausts are led to the low-pressure heater and the remainder of the exhausts to the high-pressure feed heater. A pressure up to 15 lb. may be maintained in the auxiliary exhaust pipes and thus make it possible to heat the feed water through a greater range.

A third sketch, Fig. 1, showed the arrangement used on some recent large war vessels in which feed heating is done in two stages. In a small direct-contact heater of light weight fitted to the feed tank, the feed is raised in temperature by contact with auxiliary exhaust steam to about 140 deg. F. It is then heated to over 200 deg. F., also by auxiliary exhaust steam in small surface feed heaters placed in the stokeholds and fitted on the feed discharge pipes. The preliminary heating enables a great reduction to be made in the size and weight of the high-pressure heaters.

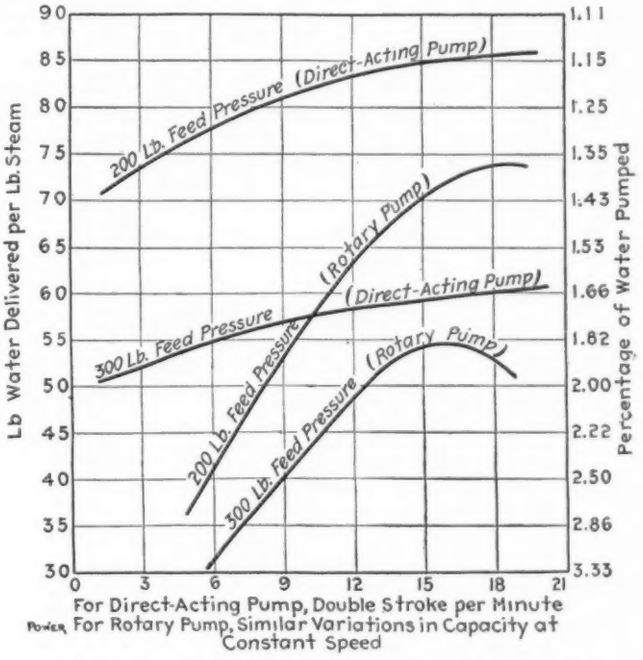

Lb Water Delivered per Lb. Steam
Percentage of Water Pumped
200 Lb. Feed Pressure (Direct-Acting Pump)
(Rotary Pump)
(Direct-Acting Pump)
300 Lb. Feed Pressure
200 Lb. Feed Pressure
(Rotary Pump)
300 Lb. Feed Pressure
For Direct-Acting Pump, Double Stroke per Minute
For Rotary Pump, Similar Variations in Capacity at Constant Speed
POWER

FIG. 2. STEAM CONSUMPTION OF FEED PUMPS

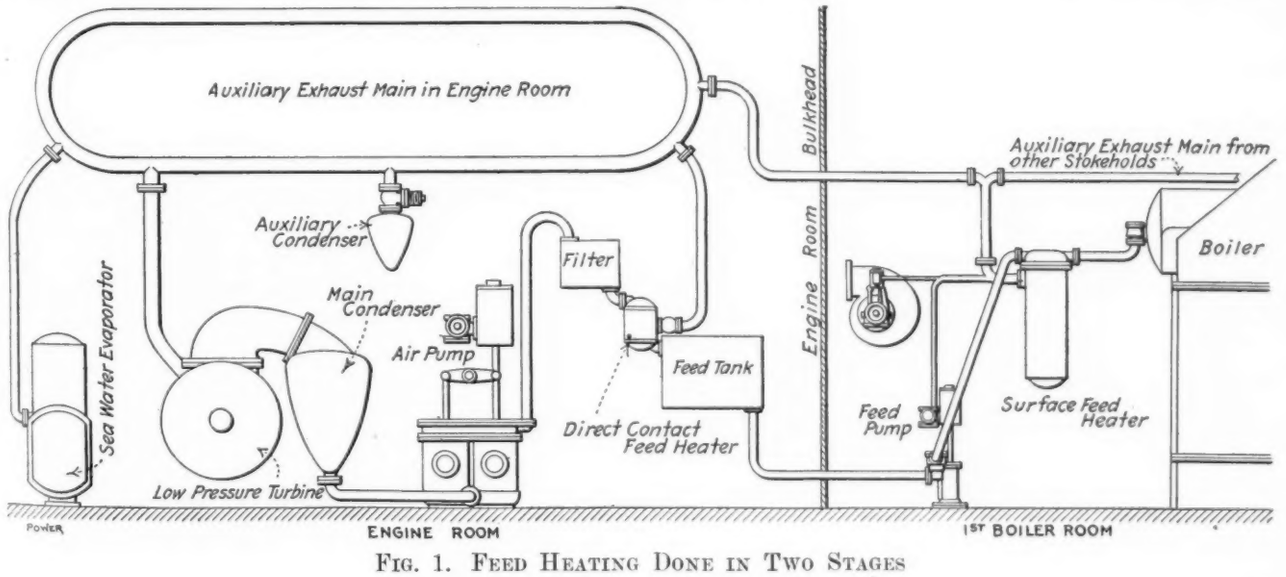


FIG. 1. FEED HEATING DONE IN TWO STAGES

INDEPENDENT FEED PUMPS

A detailed history of the development of the independent feed pump would be largely a recital of endless experiment with and investigation of mechanical details. The difficulty of regulating a crank-driven machine, together with the great and variable stresses, rendered this

type quite inapplicable for high-pressure boiler feeding. Stroke variation and high steam consumption, together with the multiplication of parts, similarly handicap the duplex type. Accordingly the single direct-acting pump has become the standard, and when arranged in conjunction with feed heater or tank float control, this type has become universal in its use.

The general and even the detail design of the pump ends, which at one time varied mainly in their degrees of inefficiency, has now become standardized by almost all makers adopting the same design, and the remaining difference of the many types, apart from workmanship and material, lies in the steam distribution valves.

A point of interest in direct-acting feed pumps is the steam consumption at varying speeds and boiler pressures. Fig. 2 shows a set of curves which represent neither the best nor the worst performances, but which can be taken as representative of actual every-day practice.

During recent years a certain amount of experimental work has been carried out with rotary feed pumps of the centrifugal type, and on the Continent a number of these have been installed in electric power stations. The application of this type of pump to marine use is of great interest, and it is rather unfortunate that the bulk of the experience obtained on shore has been with electrically driven centrifugal pumps. If it were possible, or even prudent, to drive marine feed pumps by electric motors, then it is believed their adoption would be rapid on account of the properties of the electric motor as regards nonvariation in speed, and in this connection it is more than questionable whether electrically driven feed pumps constitute good practice even for electric power stations. On board ship the feed pumps should be driven in every case by the same source of power that actuates the main machinery, and this at once involves the adoption of either a rotary steam engine or a steam turbine in conjunction with the centrifugal pump.

On the steam-consumption diagram for direct-acting pumps, there is also shown the performance of the turbine-driven type, and as will be seen, this type is considerably less economical. In the future this feature may be improved, while as a counterbalancing advantage for certain conditions the weight comparison is given in the accompanying table, which shows the relative weights of direct-acting pumps for different classes of vessels, and discloses a very large possible reduction by the rotary pump.

COMPARATIVE WEIGHTS OF INDEPENDENT FEED PUMPS

Class of Vessel	Feed Pipe Pressure, lb. per sq.in.	Weight of Pump per Hp. of Main Engines
Cargo vessel	210	0.74
Mail steamer	210	0.72
Channel steamer	210	0.665
Battleship	285	0.64
Destroyer	285	0.43
Weir "Rotofeed" Pump	285	0.14

Guarantees on Steam Generating Units

By T. A. Peebles

SYNOPSIS—The usual method of guaranteeing boiler equipment upon the performance of the whole unit is unsatisfactory, for in case of failure to meet the guarantees it is difficult to fix the responsibility between the boiler, stoker, economizer, draft apparatus, etc. To obviate this the heat balance is recommended.

The purchaser of power-plant equipment wants to know what the manufacturer will guarantee his apparatus to do in actual service and contracts often contain guarantees of capacity, efficiency and repairs. Acceptance tests are run soon after the apparatus is put into operation and the final payment on the purchase price depends upon the outcome of these tests.

The engine or turbine builder guarantees a certain capacity and water rate under stated conditions of steam pressure, moisture or superheat in the steam, and exhaust pressure. The generator man also has a definite basis upon which his guarantee is made and a fair degree of accuracy can be secured on tests.

In the boiler room, the problem is much more complicated and the large number of variables in connection with the boiler test renders it more difficult to secure accurate results. In a modern plant, the steam-generating unit consists of a boiler, stoker, draft apparatus, and probably superheater and economizer. Under the present method of basing the performance of the complete unit on the combined efficiency which is defined as the heat absorbed by the unit per pound of coal divided by the total heat in one pound of coal as fired, a disagreement is almost sure to result among the manufacturers of different apparatus comprising the complete unit in case the test does not meet the guarantee. The guarantee usually specifies that with coal containing stated percentages of moisture, volatile and ash and a certain number of B.t.u. per pound, the guaranteed capacity and efficiency will be developed.

If the capacity falls short, the stoker manufacturer has the excuse that the other parts of the complete unit offer abnormal restrictions to the flow of gases, reducing the furnace draft to a point at which it is impossible to burn the amount of coal required to develop the guaranteed capacity. He may also question the ability of the draft apparatus to take care of a sufficient volume of gases. The other interested parties may take the position that the stoker and furnace are not properly designed to burn the particular coal that is being used and the purchaser is placed in the difficult position of being required to determine just where the fault lies and which part of the unit must be altered to give the desired overall results.

The accurate determination of efficiency is even more difficult. The scales used in weighing coal and water may be calibrated before the test but they are exposed to dirt, water and rough usage during the test and cannot be relied upon to remain accurate unless handled very carefully. With the alternate method of starting and stopping the test, which is almost universally used, it is impossible to estimate accurately the amount of coal in the furnace at the beginning and end of the test. The error thus introduced may be practically eliminated by running a test of at least 24-hr. duration, but long tests are expensive and, in the end, the purchaser bears the expense, as this item is included by the manufacturer in his price.

The source of greatest error is the sampling and analyzing of the coal. If the coal is high in ash and contains some slate and dirt, a difference of 5 per cent. in the B.t.u. of two samples from the same coal pile, as shown by analysis, may easily result. Separate analyses of coal from the same sample may also differ considerably as may be seen from the following table which shows results secured by two well equipped laboratories from coal samples as nearly identical as could be picked by a man accustomed to sampling coal:

	B.t.u. Per Pound			
Sample	Laboratory A	Laboratory B	Difference	Per cent. Difference
1	13,585	14,469	+884	+6.5
2	14,400	14,215	—185	—1.28
3	13,529	13,984	+455	+3.35
4	13,747	14,045	+298	+2.16
5	13,572	14,501	+929	+6.84
6	14,155	14,797	+642	+4.50
7	14,141	13,970	—171	—1.21
8	13,667	14,277	+610	+4.45
9	14,240	13,759	—481	—3.5
10	13,892	14,607	+715	+5.65
		Average.....	531	3.9

As stated, these analyses were made in well equipped laboratories and the average percentage of difference represents the probable error in the determination of the heat value of the coal. Laboratory A secured higher heat values than laboratory B on some samples and lower values on other samples, showing that the differences as tabulated are not due to a constant error in the calorimeters used.

When two separate analyses are made of the coal used on an acceptance test, it may happen that the guaranteed results have or have not been secured, depending upon which analysis is used. This usually leads to a difference of opinion which can only be settled by running another test at considerable expense both to the purchaser and the manufacturers.

The heat balance which is coming into general use in analyzing results of boiler and furnace performance affords a more scientific and satisfactory basis for guarantees than the old combined efficiency test. The heat losses, instead of the heat absorbed by the boiler, form the basis for calculating the efficiency and the furnace and boiler losses are definitely separated. The furnace and grate losses are:

1. Heat loss, due to combustible in ash.
2. Heat absorbed by excess air up to the temperature of the steam.
3. Heat loss due to production of CO.

The stoker manufacturer is concerned with these losses only and should not be held responsible for what happens after the products of combustion leave the furnace. He should guarantee to burn a certain amount of coal per square foot of grate surface per hour with a given draft in the furnace, the rates of combustion being given for various draft intensities in the furnace throughout the range of capacity. He should also state the percentage of combustible in the ash and the analysis of furnace gases with which he will effect this combustion.

The boiler losses are:

1. Heat loss due to temperature of the flue gases above the temperature of the steam.
2. Heat loss due to air leakage through the boiler setting.
3. Heat loss due to radiation.

The boiler manufacturer's guarantee should, therefore, specify the flue-gas temperatures for the various rates of combustion given in the stoker guarantee. The draft loss through the boiler for each rate of combustion should also be stated to guard against too close baffling of the boiler in an effort to reduce flue-gas temperatures. The loss due to leakage through the setting can be determined by comparing an analysis of the flue gases at the boiler damper with the analysis of the furnace gases, and the boiler guarantee should state the analysis at the damper after knowing the guaranteed analysis at the furnace. The loss due to radiation cannot easily be determined, but if the boiler walls are of sufficient thickness, careful inspection while the brickwork is being set, will give assurance that this loss is not excessive. The boiler guarantee should specify the percentage of moisture in the steam at different rates of combustion.

With the information contained in furnace and boiler guarantees, the manufacturers of economizers and superheaters can intelligently determine and state the performance of their apparatus. Each manufacturer of apparatus going into the complete unit should be advised of the guarantees of the others, particularly as to draft losses. The draft apparatus must provide sufficient draft intensity to overcome the losses of all apparatus in the path of the gases and still provide the required draft in the furnace and must be of such capacity that it can maintain this draft intensity when handling the volume of gases resulting from the combustion of the maximum amount of coal to be burned.

The foregoing method of stating guarantees clearly defines what each part of the unit must do and enables the man in charge of a plant to determine who is responsible in case the overall efficiency is low. It prevents the shifting of this responsibility which may occur if all the apparatus comes under one general guarantee and it also establishes standards of draft, flue-gas temperature and flue-gas analysis which give the operating engineer a simple and accurate means of determining what his boiler and furnace equipment is doing.

The Sarco Automatic Grease Lubricator

This lubricator is made in two types, one actuated by a pendulum, for moving bearings, such as crossheads, cranks, etc.; the other actuated by clockwork in a dustproof casing and used for stationary and slow moving bearings. Both lubricators feed grease in the same manner.

In the pendulum type, the pendulum, instead of a spring, actuates the clock movement and consequently when the bearing stops moving the pendulum the feeding of the grease stops simultaneously.

The body of the cup is of gun metal and screws to the bearing. Grease is pressed down into the bearing by a piston, operated by the clockwork, which is placed in a hermetically sealed casing. The speed of the piston depends on the thread of the spindle, six different sizes being provided to suit various conditions.

The clock is wound up daily. If more grease is delivered than required the clock stops automatically. It restarts as soon as the bearing requires lubrication. A lever on the cover of the lubricator releases and stops the clock. These lubricators are manufactured by the Sarco Engineering Co., 116 Broad St., New York City.

ELECTRICAL DEPARTMENT

Protective Relays

By H. R. Stickney

The purpose of protective relays is to protect the system from the destructive effects of short-circuits, excessive overloads, excessive voltage, reverse currents, etc. A number of different types are on the market, but, as they all operate on very much the same principle, only the three most important types will be discussed. These are the instantaneous, the inverse time-limit and the definite time-limit relays.

The instantaneous relay is designed to operate at a predetermined current value, usually the limiting capacity of the apparatus. It consists of a solenoid, the plunger of which carries at its upper end a device for closing or opening an independent circuit, which in turn will open or close the oil switch or circuit-breaker on its respective circuit. The current value at which these relays will operate is determined by setting the height the plunger will have to rise to close its relay contacts. This is done by a small thumb-screw at the bottom of the plunger casing, which by turning, lowers or raises the plunger.

A series transformer is used in connection with these relays to control the current in the relay itself, for it would be impractical to have the total line current pass through the relay. The primary of these transformers consists of one straight bar about which the secondary is wound, the primary being connected in series with one phase of the feeder; see Fig. 1. The secondary, as stated, is wound upon the primary, the number of times bearing any desired ratio to the primary. Since there is no iron present in the transformer, this ratio will remain practically constant at all loads.

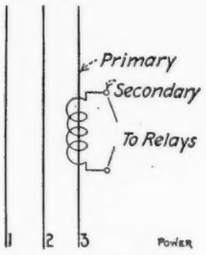


Fig. 1. Transformer

In a transformer having a ratio of 50:1, only $^1/_{50}$ of the current in the feeder would be induced in the secondary and flow through the relay. Most relays are graduated for from 5 to 10 amp. for their operation and assuming this basis, suppose it is desired to open a feeder when the load reaches 250 amp. Since the transformer ratio is 50:1, the current passing through the secondary to the relay would be

$$\frac{1 \times 250}{50} = 5 \text{ amp.}$$

And at this value the relay would be set to operate.

The usual method of protecting a three-phase system is by using two relays and their respective transformers connected as shown in Fig. 2. The ground connection shown is so placed on the common return wire that it may act on both transformers, its purpose being to protect the operator, instruments and relays from the high potential of the feeder if the insulation of the transformer should break down.

Now consider the operation of the system. If phase No. 3 should become overloaded, transformer *A* would

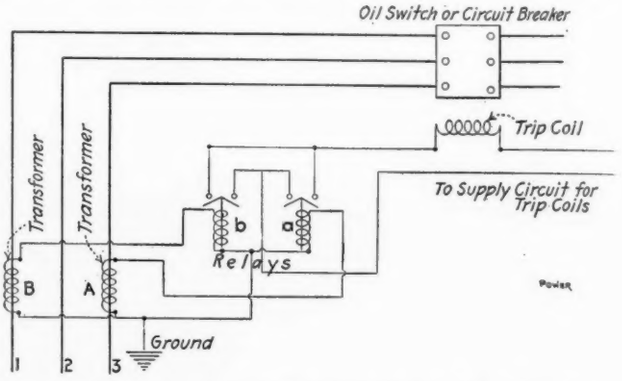


Fig. 2. Three-phase System with Two Relays

respond, causing relay *a* to operate and close its respective circuit tripping the coil of the circuit-breaker. Similar action would take place in case phase No. 1 were overloaded. The trip coils are usually wound for 125 volts at 5 or 10 amp. and are operated from storage batteries or other independent low-potential sources.

The inverse time-limit relay is similar to the instantaneous relay, with the exception that at the contact end of the plunger is placed a small bellows fitted with an adjustable air-valve. As the plunger rises its speed is retarded, due to slowly forcing out the air in the bellows through the air valve. The heavier the overload, the greater the force spent upon the bellows and therefore the air is expelled at a grater rate, allowing the contacts to close more quickly; that is, the time of closing varies inversely as the magnitude of the disturbance—hence, the name "inverse time-limit relay."

The definite time-limit relay is similar except that between the bellows and the plunger is interposed a small spring which is acted upon, giving a definite period of time which varies directly with the adjustment of the air valve at the top of the bellows. Some makers use a gravity accelerated dashpot with a similar air valve: this depends upon the plunger to allow the contact rod to drop by its own weight upon release. The speed at which it descends is governed by the air valve in the dashpot.

Those types of relays explained are known as circuit-closing relays, i.e., closing the trip-coil circuit. There is another type, known as circuit-opening relays, operating the trip coils by deënergizing their respective magnets. Also, reverse-current relays are often used on direct-current generators and rotary converters to prevent a flow of current into the machines from the line.

Obtaining Wire Resistance on Slide Rule

By A. F. Moore

A very useful and easily remembered method of ascertaining the resistance of copper wire with an ordinary slide rule is as follows:

Looking at the back of the rule, set the last digit of the B. & S. gage number of the wire on the logarithmic or middle scale of the slide, opposite the hair line on the right. Turn the rule face up and read the number on the bottom or "D" scale opposite the 1 at the left end of the slide. To point off, remember that the resistance of wire from No. 0 to No. 10 is of the order of tenths, No. 10 to 20 is of the order of units, No. 20 to No. 30 is of the order of tens, etc. The result will be a very close approximation in ohms per 1000 ft. of copper wire of the size required, at 20 deg. C. With No. 11 B. & S. gage the result is exact, and the error varies from about 2 per cent. high for No. 0, to 4.5 per cent. low for No. 40. This is accurate enough for ordinary calculations. To obtain the result for No. 00, No. 000 and No. 0000, consider No. 00 as No. 9, No. 000 as No. 8, etc., and set the decimal point one more place to the left.

As an example, let it be desired to know the resistance of 1000 ft. of No. 15 B. & S. copper wire. Looking at the back of the rule set 5 on the logarithmic scale on the middle of the slide, opposite the hair line on the right-hand end of the rule. Turn the rule face up and read 3161 on the lower scale, opposite the 1 at the left end of the slide. Since No. 15 comes between No. 10 and No. 20, the resistance will be of the order of units, or 3.161 ohms per 1000 ft. If the wire had been No. 5, resistance would have been 0.3161; if No. 25, 31.61, etc.

Synchronous Motors Driving Air Compressors

The use of the synchronous motor, because of inherent advantages for certain kinds of service, is now becoming more extensive. As applied to driving air compressors, an interesting installation is to be found at one of the Central Park shafts of the tunnel which is being driven under New York City in connection with the Catskill aqueduct system.

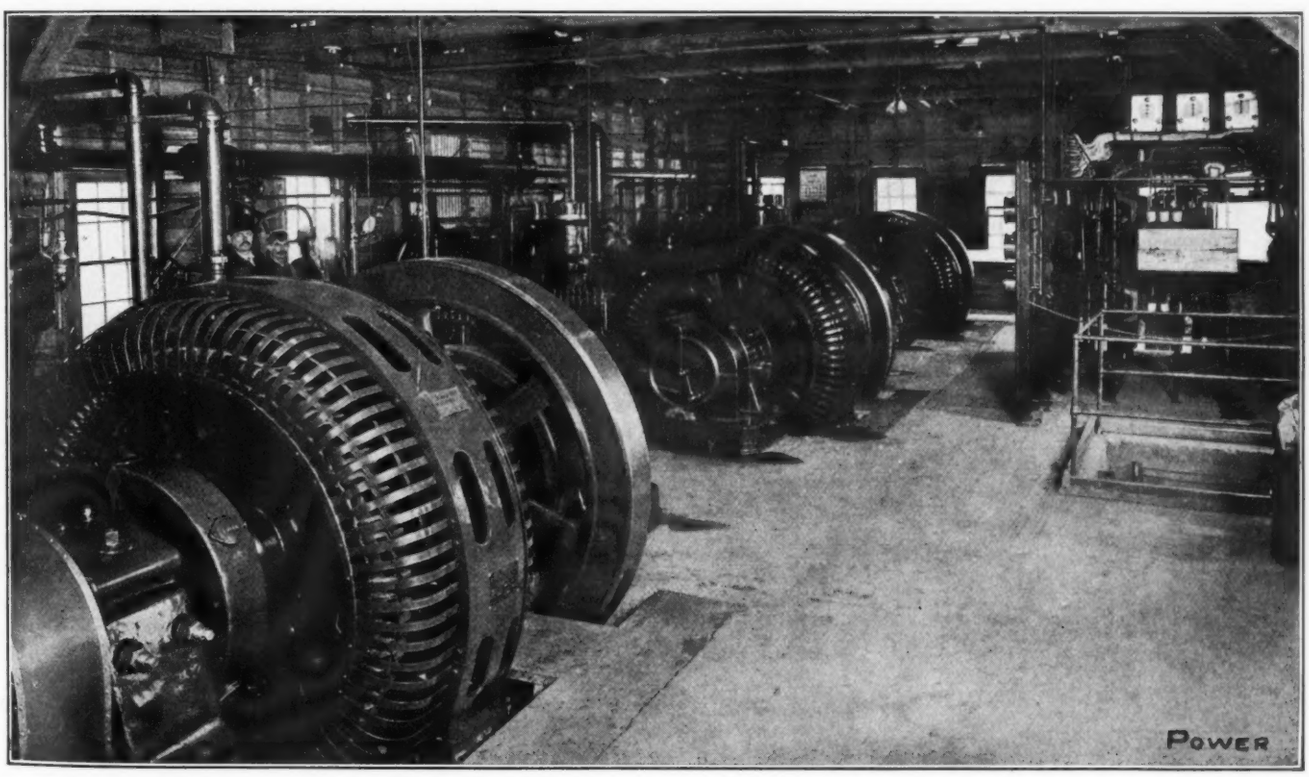
The plant, as shown, consists of three two-stage Sullivan air compressors, each coupled direct to a 400-hp., 6600-volt, three-phase, 25-cycle Westinghouse synchronous motor. The compressors furnish air for driving air drills. They are each 15½x20x18 in. and have a piston displacement of 2070 cu.ft. of air per min. at the rated speed of the motor, 187½ r.p.m.

A vertical intercooler with copper water tubes, placed between the high- and low-pressure air cylinders, provides 10.75 sq.ft. of cooling area per 100 cu.ft. of free air.

The volume of air delivered is made proportional to the demand by means of a double-beat unloading valve on the air inlet of the intake cylinder. This valve is either fully open or tightly closed, so that there is no choking effect on the entering air. A 3½-ton flywheel renders the operation of the outfit smooth and eliminates any objectionable peaks in the power-consumption curve.

A particular advantage of this type of motor is that, in addition to its use as a motor, it may be employed as a synchronous condenser to improve the power factor of the circuit, this being accomplished by adjusting the field excitation.

Direct current at 125 volts is furnished for the field excitation by an exciter mounted on the compressor frame



Synchronous Motors Driving Air Compressors at Aqueduct Shaft

and driven by a belt from the crankshaft. The revolving portion of the motor is provided with a combined starting and damper winding so proportioned that the necessary starting torque is developed by the minimum line current, consistent with the synchronous operation. This starting winding is similar in construction and operation to the rotor winding of the well known squirrel-cage induction motor. Tests have shown a power consugmption of 345 cu.ft. of air per kw.-hr.

Incidentally it may be mentioned that the water for this great system is to be brought all the way from the Catskills in an underground tunnel which at Storm King crosses under the Hudson River at a depth of 1100 ft.

The water is to be carried from Ninety-ninth St. to Fourteenth St., Manhattan, a distance of 4.38 miles, in a tunnel cut through solid rock its entire length, about 225 ft. below the level of the street. It has a finished bore of 14 ft. inside the concrete lining down to Forty-second St., 13 ft. to Twenty-third St., and 12 ft. from there to Fourteenth St.

The six shafts sunk are located as follows: Three in Central Park, at Ninety-third St., Eighty-first St., and Sixty-sixth St.; one at Fiftieth St. and Fifth Ave.; one at Forty-second St. and Bryant Park; and one at Twenty-fifth St. and Broadway.

Signal System

In power plants where the generators are located some distance from the switchboard some reliable system of signals between the engineer and the switchboard operator is necessary. The following is a description of the system I have installed in connection with one of our 1500-kw. units.

I first made an 18x10x6-in. box of wood lined with asbestos and divided it into six compartments in each of which was mounted an 8-cp. lamp. On a piece of tracing cloth just large enough to cover the front of the box the signals were painted so that one signal would be over the lamp in each compartment. The signals were: "On," "Off," "Slow," "Fast," "Coming On" and "Coming Off." This box was mounted on top of the gage board where it could be plainly seen by the man at the engine throttle.

On the generator oil switch were mounted two contacts connected to the signals "On" and "Off"; a pull-and-push switch normally open was mounted on the generator panels and connected to the signals "Slow" and "Fast." Just below the synchronizing plug receptacle was mounted a single-pole double-throw knife switch, so mounted that in the up position the handle prevented the plug from being inserted. This plug was connected to the signals "Coming On" and "Coming Off," so that in throwing down the switch the engineer is notified that the operator is ready to synchronize. A lamp was also mounted on the signal box and connected to the synchronizing busbar, which permits the engineer to bring the engine to proper speed by watching the pulsations of the lamp. The operator signals if slow or fast and as soon as the oil switch is closed the signals "Off" and "Coming On" go out and the signal "On" shows up.

In shutting down the generator the operator puts the single-pole switch up and this shows the signal "Coming Off. The engineer then begins to slow the engine and as soon as the oil switch is opened the signals "On," "Coming Off" go out and the signal "Off" shows up. The operator is compelled to notify the engineer before he can synchronize.

This system has been in operation here several months and is reliable and practically fool-proof and is very valuable where the engine speed is controlled by the man at the throttle.

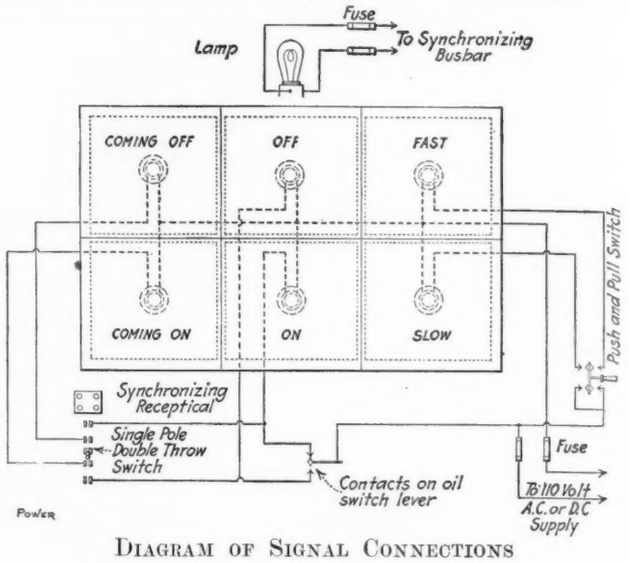


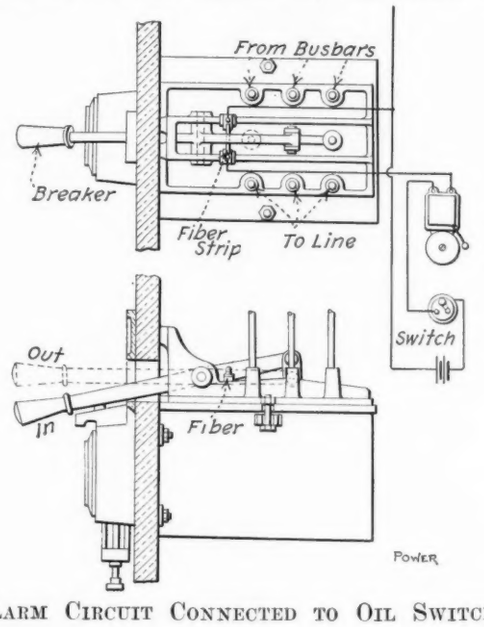
DIAGRAM OF SIGNAL CONNECTIONS

WILLIAM R. DAVIS.

Springfield, Ill.

Oil Circuit Breaker Alarm

The sketch shows a simple alarm for oil circuit-breakers, it being possible to put any number of breakers on the one circuit. The dotted lines show the breaker out, in which position the metal of the breaker makes contact with the brass, fiber-insulated strips and closes the alarm circuit, thus ringing the bell. A small switch is necessary in the bell circuit as sometimes certain breakers are not required in service.



ALARM CIRCUIT CONNECTED TO OIL SWITCH

JAMES A. CAMPBELL.

Providence, R. I.

GAS POWER DEPARTMENT

Test of Gas Producer Plant

By L. L. Brewster

The economy of a gas-power station under normal and commercial operating conditions is shown in the appended data from a five weeks' test. The owners of this plant desired to know just what results were being obtained in the gas-power plant which was installed about three years ago, and for a period of five weeks carefully measured all the necessary quantities for securing the desired information.

The plant under discussion is thoroughly modern, equipped with apparatus of approved design and operated by an engine and producer-room crew which are well above the average. The equipment consists of two bituminous producers of 250 hp. each; three double-acting tandem gas engines direct connected to 100-kw., three-phase, 60-cycle, 500-volt generators. The exciter for each generator is belt driven from a pulley on the engine shaft just outside the outboard bearing. Two or three of the units operate in parallel whenever desired, delivering current to a single set of busbars. During the five weeks' test period it was necessary to run only two engines part of the time and one engine the rest of the time; thus the third engine was, during this period, a spare unit. The producers are each pulled by a rotary exhauster which also serves as a centrifugal scrubber, the gas first passing through a static scrubber and cooler. The exhausters deliver their gas through a common main to a small holder whose capacity is too small to make it of service except as a pressure regulator. It is so weighted that gas reaches the engines at about atmospheric pressure or slightly above.

During the test period the load on the engines was frequently a maximum for short periods and this made it necessary to run two engines, although, as shown by the data, the average load per engine was slightly over one-half its rated capacity.

The fuel consumption noted is the total for the period and therefore includes the consumption during standby periods as well as during periods of operation. An analysis of the data given will show that the load-factor for the entire period was comparatively small. The producer plant delivered gas for the engines under load for 507¼ hr. out of a possible total of 840, or 60.4 per cent. of the time; the standby period was, therefore, nearly 40 per cent. of the total time. In the 29 days of running the engines ran a total of 565 engine hours and developed 31,592 kw.-hr. at the switchboard. At their rated capacity they would have developed during this period 56,500 kw.-hr., so that the load-factor was about 56 per cent. The total capacity of the three engines would be 7200 kw.-hr. per day of 24 hr., or 208,800 kw.-hr. for the 29 days' run, or a loading factor of about 15 per cent.

The summary of the test shows the fuel consumption per kilowatt-hour for the entire period to be 3.08 lb., and for the last two weeks of the test 2.93 lb. These figures should be considered only in connection with the conditions of the run which show that the average load on the engines for the time they were run was only slightly over one-half load, and a total standby on the producers of nearly 40 per cent. of the time.

The consumption stated is for the net power delivered to the switchboard, which, of course, does not include that necessary to drive the exciter units. This net power is not all available, however, for distribution to the factory, for about 10 per cent. of it is used for driving the rotary scrubbers and the centrifugal pumps for circulating cooling water to the engines.

Table 1 is a summary of the principal results in the producer operation for the entire test period. Table 2 is a sample log of a week's run. In Table 3 is shown the

TABLE 1. SUMMARY OF FIVE WEEKS' TEST ON GAS PRODUCER

	Gas Registered by Meter	Gas Corrected to 60 deg. F.	Fuel Used in Coal Equiv. (Lb. of coal =0.875+Lb. of Coke)	Gas per Lb. of Fuel Corrected to 60 Deg. F.	Average Fuel per Day, Lb.	Producer Hours	Total Kw.-hr. at Switchboard
Week Aug. 26-31, 6 days	1,478,000 25,600 (Used at dryer metered separately	1,399,818 25,000	14,780 (coal) 2,450 (coke) 16,924 (total fuel)	96.4 (coal) 84.2 (fuel)	2,463 coal 409 coke	98¼	4,620
Week Sept. 3—7, 5 days	1,452,400	1,368,412	14,233 (coal) 1,313 (coke) 15,382 (total fuel)	96.1 (coal) 89.0 (fuel)	2,486 coal 239 coke	100	5,260
Week Sept. 9—14, 5 days	1,569,600	1,468,417	17,737 (coal) 1,312 (coke) 18,885 (total fuel)	82.6 (coal 77.8 (fuel)	2,964 coal 239 coke	98¼	5,321
Week Sept. 14—21, 6 days	Meter stopped on Sept. 19, repaired Sept. 22	2,028,000 (calculated using 251 cu.ft. per kw.)	19,947 (coal) 2,275 (coke) 21,938 (total fuel)	101.7 (coal) 92.4 (fuel)	3,325 coal 379 coke	99	7,890
Week Sept. 23—28, 6 days	2,197,200	2,088,278	22,118 (coal 2,275 (coke 24,109 (total fuel)	94.4 (coal) 86.6 (fuel)	3,686 coal 379 coke	111¼	8,510
Totals		8,377,925	88,815 (coal) 9,625.(coke)			507¼	31,592
	On first 3 weeks siderable gas was blasted up the stack in order to keep the fires in the producer hot, especially on Sept. 9—14. This gas could not be metered.	Average fuel per kw.-hr. during whole test, test 3.08 lb.	Average fuel per kw.-hr. during last two weeks 2.93 lb.	All B.t.u. determinations and analyses were made from gas taken from the holder. Gas passing from the producer to the holder showed a much greater fluctuation.			

gas consumption of the engines for a week's run, and Table 4 is a record showing the variation in gas quality for a considerable period of time during one day, and also shows a sample gas analysis and an engine exhaust analysis.

TABLE 2. LOG FOR WEEK'S RUN

Date	Producer	Engine, hours run	Gas pressure, inches of water	State of meter	Actual gas psased, cu.ft.	Corrected gas passed, cu.ft.	Hours run for producer	Gas per hour	Coal per hour, aver- lb.	Coal for week, lb. coal	Cu.ft. gas per lb. coal	Total kolowatt hours	Remarks
Sept. 23.....	No. 1	Nol 1- 9½ No. 3-10½	4.4	At start 6 a.m. 5,831,100 cu.ft. At end 4.30 p.m. 6,100,500 cu.ft.	269,400	260,394	11½	22,643	199.8	22,118 2,275 (coke)	94.44 86.6 (with coke)	1080	No slow downs Very cloudy Humid
Sept. 24.....	No. 1	No. 1- 9½ No. 3-16¼	4.4	At start 6 a.m. 6,100,500 cu.ft. At end 12 m. 6,433,700 cu.ft.	343,200	327,567	16¼	20,158				1370	No slow downs Rain
Sept. 25.....	No. 1	No. 1- 9½ No. 3-22½		At start 12 m. 6,443,700 cu.ft. At end 12 m. 6,849,700 cu.ft.	406,000	384,226	22½	17,077				1620	No slow downs Rain unitl 12 m.
Sept. 26.....	No. 1	No.1- 9½ No. 3-22½		At start 12 m. 6,849,700 cu.ft. At end 12 m. 7,255,200 uc.ft.	405,500	383,753	22½	17,056				1600	No slow downs Clear
Sept. 27.....	No. 1	No.1-13¾ No. 3-18½		At start 12 m. 7,255,200 cu.ft. At end 12 m. 7,682,100 cu.ft.	426,900	404,004	22¼	18,157				1610	3 min. interruption No. 3 engine stopped on night run. Rain in a.m. Clear inp.m.
Sept. 28.....	No. 1	No. 1-11½ No. 2-14½		At start 12 m. 7,682,100 cu.ft. At end 4. 30 8,028,300 cu.ft.	346,200	328,333	16½	19,900	Had to shoot fire 8 times today to capacity of 2 engines, maximum vacuum 15 inches			1230	No slow down Clear
Total.....				2,197,200	2,197,200	2,088,277	111½					8510	

The gas was also sampled for determination of the quantities of tar and dust and an average of all the samples taken showed that there was no tar present in the gas, but there was a dust content of 0.044 gr. per cu.ft., the sample being taken at the scrubber outlet. A computation of the amount of sulphur in the gas showed that the gas contained 0.001 per cent. of sulphuretted-hydrogen (H_2S). This computation was made on the assumption that one-half of the total sulphur in the coal was gasified and that the sulphur content of the coal was 1.2 per cent., as shown by the analysis.

TABLE 3. GAS CONSUMPTION OF ENGINES

		Cu.ft. gas at 60 deg. F.	Total kilowatt hours at Switch-board	Cu.ft. gas per kw.-hr. at 60 Deg. F.	Kilo-watts per Engine-hour	Remarks
Sept. 23.	Day	260,394	1,080	241.1	54.7	
	Night	Did not run	0	0	0	
Sept. 24.	Day	264,855	1,070	247.5	54.2	
	Night	138,211	530	260.8	44.1	
Sept. 25.	Day	245,538	1,080	227.3	54.0	
	Night	142,596	540	267.8	45.0	
Sept. 26	Day	239,582	1,060	226.0	53.0	
	Night	143,834	530	271.4	44.1	
Sept. 27.	Day	252,572	1,060	238.2	53.0	3 min. interruption due
	Night	158,820	540	294.1	46.0	to engine No. 3 off line on night run.
Sept. 28.	Day	249,673	1,020	244.8	51.0	Shot fires eight times to
	Night	Did not run	0	0	0	allow capacity of exhauster to give sufficient gas for two engines for this day's run. Maximum vacuum 15 in.
Total.		2,096,075 2,088,278	8,510			22,118 lb. coal per week 2,275 lb. coke per week 2.60 lb. coal per kw.-hr. 0.27 lb. coke per kw.-hr.
Aver				246.0	49.91	
		Disparity in figures is due to a slight difference in conversion factors for each day. Uncorrected gas 2,197,200 cu.ft. registered on meter.				Two engines on during day only. One engine on during night.

The reader should bear in mind that these results were obtained by simply measuring the necessary quantities for a period of five weeks, during which time conditions were simply those demanded of the power plant in supplying electric power to the factory in which it is situated. Under favorable conditions this plant has, to the writer's knowledge, developed a brake horsepower-hour on slightly less than one pound of coal, such as was used in this test. The effect of the load-factor and the loading factor in this particular case is to increase the fuel consumption to about twice this amount.

TABLE 4. GAS QUALITY AND ENGINE EXHAUST COMPOSITION.

Sept. 13. 1912.

Time	B.t.u. at 60°F.
7:00	87.5
7:15	91.8
7:30	101.0
8:00	100.5
8:15	99.1
8:30	103.3
9:00	110.1
9:30	109.3
10:00	106.9
10:30	105.0
11:00	106.4
11:30	103.4
12:00	101.8
12:30	101.4
1:00	110.3
1:30	108.0
2:00	105.1
2:30	106.5
3:00	106.5
3:30	107.7
4:00	110.7
4:15	110.3

Gas Analysis — 10.10 a.m.

	Per Cent.
CO_2	8.0
O	0.2
CO	17.0
CH_4	0.8
H	13.5
N	60.5
	100.0

Exhaust from engine No. 2.

	1 p.m.	1:35	2:05	2:45
CO_2	14.0	12.0	12.5	15.2
O	4.0	4.4	5.7	3.0
CO	0.0	0.0	0.0	0.0

Eureka coal analysis:

	Per Cent.
Moisture	1.47
Volatile matter	13.70
Fixed carbon	76.94
Ash	7.89
	100.00
Sulphur	1.2

Blasting up stack until 10 a.m.

Average—104.3 B.t.u. per cu.ft.

Operating Results with Diesel Engine

As a great deal is known about the construction of Diesel engines but not so much about operating results in actual practice, the following extract from a report of the engineer-in-chief of the Hamburg-American liner "Christian X," about his experience on the first trip from Hamburg to Havana will be of interest. The report says:

"The pistons and cylinders of the main engines have given no trouble, but it will take another 10 or 15 days before the inner surfaces are quite polished, whereupon it is hoped to reduce the lubricating-oil consumption from 26 to 23 lb. per 24 hr. Heavy, dry deposits were found on the pistons and cylinder interiors, due probably to the high ash and sulphur content of the fuel oil used. All the exhaust valves had to be exchanged after the voyage

was completed, as they showed deep grooves at the tapered seats, which are very likely due to the same cause. Nearly all the valves and seats must be reground. The tanks containing compressed air for the fuel injection had to be emptied every two hours of water which accumulated, as the atmosphere contains considerable moisture. Closing against a pressure of 60 atmospheres the valves—admitting compressed air from the tanks—can only be opened slightly. But the severe throttling which thus results causes leakage of these valves after some time. This could be avoided if a second valve were interposed, which effects the throttling, while the first named valve on the air tank is opened to the full extent. All bearings, as well as the guides, of both engines were carefully inspected but no appreciable wear was found.

"Between July 26 and 27, a trial run of 24 hr. took place, during which the two main engines as well as the auxiliary compressor were indicated every 4 hr. The following data were obtained:

"Output of the two main engines, 2383 i.hp.; fuel consumption of these engines, 8.5 tons in 24 hr., or 0.32 lb. per i.hp.-hr. The capacity of the auxiliary compressor was 216 i.hp., and its fuel consumption in 24 hr. 1848 lb., or 0.35 lb. per i.hp.-hr. The total fuel consumption for the main and auxiliary engines amounted to 9.3 tons in 24 hr., or, referred to the output of the main engine, 0.36 lb. per i.hp.-hr.

"During the whole journey the main and auxiliary engines worked satisfactorily and without interruption, and the exhaust of all engines was free from soot."

CORRESPONDENCE

Trouble with Gas Meter

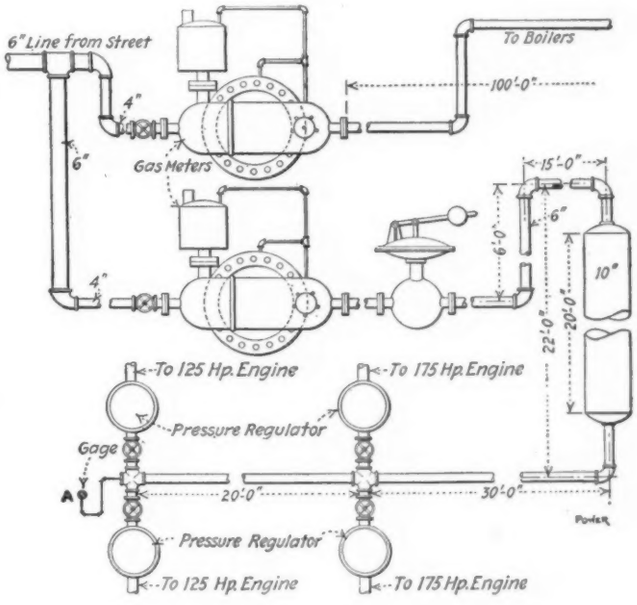
Our power plant in a large office building, consists of four gas engines amounting in all to 600 hp., which furnish all the light and power. Two 54 in. x 16 ft. fire-tube boilers are used for heating only.

Two of the engines are run during the day time and one at night; one boiler is fired at a time and that only in winter . As will be seen by the accompanying sketch our gas supply comes from the street through a 6-in. line, inside of the building it branches off into two lines each 4-in. and leading to two 4-in. gas meters, each meter having a rated capacity of 10,000 cu.ft. per hr. One meter is on the gas engine line and the other on the boiler line. The boiler line continues with a 4-in. pipe to the boilers, with 100 ft. of pipe between the meter and the boilers.

The gas engine line after leaving the meter leads to a 4-in. pressure reducing regulator, after passing which it is increased to 6 in. for 25 ft., and then opens into a 10-in. manifold 20 ft. long; from the manifold it is again reduced to 6 in. for a distance of 30 ft. Off from the last 20 ft. the connections for the four engines are made. Each engine has its own pressure reducing regulator which reduces the pressure from 6 oz. to that of the atmosphere.

The two engines (one 125 hp. the other 175 hp.) that run each day do not at any time carry over 75 per cent. of their rated load. The consumption of gas by the engines in 24 hr. average from 42,000 to 46,000 cu.ft. and the highest hourly rate does not exceed 3000 cu. ft. per hr. The highest consumption on the boilers seldom goes above 60,000 cu.ft. in 24 hrs. on a very cold day, while it generally ranges from 30,000 to 50,000 cu.ft. according to the weather. The line pressure at the meters is 8 oz., the regulator on the engine line is set for 6 oz. and at any time when two or even three engines are running the gage *A* at the end of the engine line always shows 6 oz., and never indicates any fluctuation in pressure on the line.

Yet the gas company repeatedly complains that the gas engines strain its meters and that it has to change them oftener than on the boiler lines.



CONNECTIONS TO ENGINES AND BOILERS

I have never been able to understand this as the meters have a capacity of four to six times the amount used, and the gas pressure is always up to standard. If the pressure occasionally dropped so that the engines would pump the gas, there might be a cause, but with the pressure always up I cannot find an explanation of the difference. The only answer obtained from the gas company is that its meters on gas engines when brought into the repair shop are in worse condition than any others which it has in service.

L. M. JOHNSON.

Emsworth, Penn.

Gas Engines in Pittsburgh Hotel

Three 150-hp. Bruce-Macbeth engines have just been installed in the Fort Pitt Hotel, Pittsburgh. Each engine is direct connected through a link coupling to a 100-kw., three-wire, direct-current generator, and is to run in parallel with steam units previously installed. The engines are equipped with double-magneto igniters and with gas-economy indicators, which shows instantly the consumption of gas per kilowatt-hour for each engine independently.

Power from this plant is used for both elevator and lighting service and for some twenty motors for various purposes about the hotel.

HEATING AND VENTILATION

Use of Pitot Tube in Air Measurements

By Frank L. Busey

There are a number of methods used to measure the velocity or volume of a current of air, depending on conditions, such as the object of the test, the degree of accuracy desired, or the general arrangement of the installation. For many purposes, such as measuring the velocity of the air leaving a register, the anemometer will answer. For fan testing or for determining the quantity of air flowing through a system of ducts or piping, the pitot tube is more accurate and is easy to manipulate. That it is not more extensively used is probably due to the fact that it is not more generally understood.

Operation and Form of Tube

The pitot tube is an instrument used for making velocity measurements of a current of air, the principle of its action being shown by Fig. 1. When there exists through a system of piping a flow of air, due to a certain pressure, a part of this pressure, termed the "velocity head" or "velocity pressure," is transformed into velocity, while the balance, termed "static head," serves to produce pressure. The sum of these two make up the total head or pressure, also frequently referred to as "dynamic head."

Either the total pressure or static pressure may be read from a gage, but the velocity pressure is determined indirectly. If a bent tube with an open end be inserted in an air duct, as at B in Fig. 1, with the open end facing the air current, a pressure, due to both the velocity and static head, will be produced in this tube. This is the total or dynamic head, and the amount can be read on an attached gage or manometer tube. If instead of a bent tube, a straight tube be inserted, as at A, the difference in levels in the manometer tube will indicate the static head or pressure. The velocity head or pressure may then be determined by subtracting the static from the total manometer reading.

The pitot tube as ordinarily used is an instrument combining the two tubes just described, as shown at C, the outer ends being connected to the two legs of the same manometer. By this means the subtraction is made automatically and the difference as shown by the gage is due to velocity pressure only. These tubes are usually combined in some such form as shown in Fig. 2.

Great care should be taken to keep the tube fixed in a position exactly parallel to the direction of flow, as only when in this position will the reading be correct; it should be pointed against the direction of flow. A convenient form of gage for use with low pressures is the ordinary Ellison differential draft gage. The pressure may be read either in inches of water or of mercury.

Theory of Pitot Tube

This is thoroughly discussed by Frank H. Kneeland, together with a study of some of the different forms, in a paper read before the American Society of Mechanical Engineers, in December, 1911. Having determined the velocity head as above explained, the actual velocity may be calculated by means of the formula.

$$V = \sqrt{2gh}$$

where

V = Velocity in feet per second;
g = Acceleration due to gravity in feet per second;
h = Velocity head in feet of air.

Let V_1 = velocity in feet per minute. Then

$$V_1 = 60\sqrt{2gh}$$

The value of h in the above formula is expressed in head of air in feet, whereas the measurements taken are

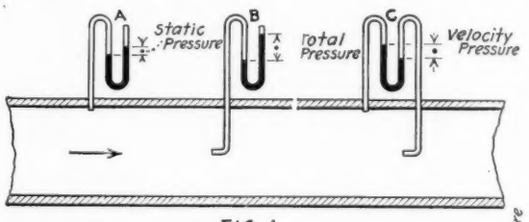


FIG. 1

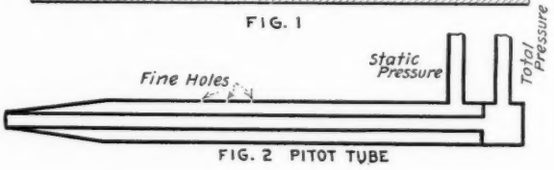


FIG. 2 PITOT TUBE

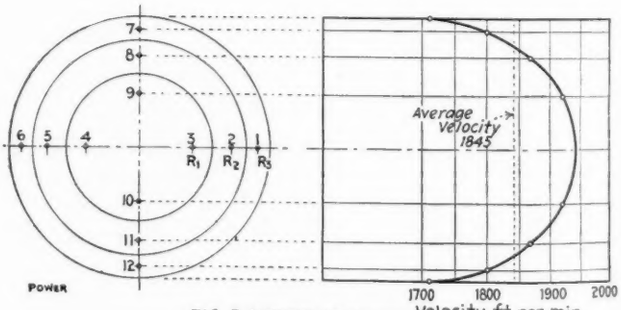


FIG. 3 METHOD OF MAKING PIPE TRAVERSE

ordinarily h_1 = head of water in inches as read on the manometer. Letting w = weight of air per cubic foot and d = density of water in pounds per cubic foot, gives

$$V_1 = 60\sqrt{\frac{2gh_1d}{12w}} = k\sqrt{h_1}$$

With air at 70 deg. and 29.92 in. barometer, $d = 62.31$ and $w = 0.07494$, whence the above formula becomes

$$V_1 = 60\sqrt{\frac{2 \times 32.16 \times h_1 \times 62.31}{12 \times 0.07494}} = 4005\sqrt{h_1}$$

From this it may be seen that the velocity at 70 deg. and 29.92 in. barometer, due to 1-in. pressure, is 4005 ft. per min., and the velocity at any other pressure may be determined from the above relation. That is, the velocity varies as the square root of the pressure. For any other temperature or barometric pressure the velocity may be

found by inserting the proper values of d and w in the above formula, or from the ratio of the absolute temperature or barometric pressure, since at constant pressure the velocity will vary directly as the square root of the absolute temperatures or inversely as the square root of the barometric pressures. Table 1 gives the velocity at various pressures for air under standard conditions of 70 deg. F. and 29.92 in. barometer.

These formulas may be considered sufficiently accurate for ordinary velocities, say up to 6000 ft. per min. Above that velocity and for very accurate work, various corrections should be made. These corrections, based on the experiments of Capt. D. W. Taylor, are discussed by Mr. Kneeland in the paper already referred to.

Use of Pitot Tube in Air Duct

For fan testing or in ventilation work the pitot tube may be used to determine the velocity, and hence the quantity, of air flowing through a duct or pipe. The tube should be inserted at a point where the duct is straight and the flow undisturbed. In testing a fan the pitot tube should be placed from 10 to 20 diameters from the fan outlet with the point directly facing the blast. The air pipe should be the same diameter as the fan outlet.

The velocity pressure shown with the tube in the center of the duct, will be higher than the average, and will vary at different points from the center to the sides of the duct. To obtain the true or average pressure it is necessary to multiply the velocity pressure reading obtained at the center by the proper coefficient. Various authorities give a coefficient of from 0.87 to 0.91 for circular pipes, but the results of careful experiments show that a coefficient of 0.89 for square and 0.90 for round pipes will give the true average velocity pressure when readings are taken at the center of the pipe or duct. Fairly accurate results may be obtained by multiplying the velocity at the center of the pipe by 0.95 to obtain the average velocity.

For more accurate work it is better to make a traverse of the pipe and either determine the coefficient for the case in question or take the average of all of the readings. Where the duct is rectangular it may be divided into a number of small squares or rectangles and a reading taken in the center of each. Then the average of all of the velocities corresponding to these pressures will give the true velocity in the duct. In case the pipe is round, its area should be divided into a number of concentric zones or rings of equal area, and four readings taken in each area, readings being taken horizontally and vertically across the pipe.

The position of each successive point may be found by dividing each ring into two equal areas and adding one of these to the sum of the preceding areas. The radius of this resulting area will locate the desired point.

Expressed by means of a series of formulas, these points may be found as follows:

$$R_1 = \sqrt{\frac{a}{6.2832}}$$

$$R_2 = \sqrt{\frac{a + \frac{a}{2}}{3.1416}}$$

$$R_3 = \sqrt{\frac{2\,a + \frac{a}{2}}{3.1416}}$$

$$R_4 = \sqrt{\frac{3\,a + \frac{a}{2}}{3.1416}}$$

where R_1, R_2, R_3 and R_4 = the distances from the center to the points where the readings should be taken in each successive ring, and a = the area of each zone or ring.

TABLE I. CORRESPONDING VELOCITY FOR DRY AIR AT VARIOUS PRESSURES AND TEMPERATURES

Pressure		Temperature. Deg. F.								
Inches	Ounces	50	60	70	80	100	150	200	300	500
0.1	0.0577	1242	1255	1266	1278	1,300	1,358	1,413	1,516	1,704
0.2	0.1154	1757	1776	1791	1808	1,841	1,921	2,000	2,145	2,411
0.25	0.1443	1965	1986	2003	2022	2,059	2,149	2,235	2,399	2,696
0.3	0.1730	2151	2175	2193	2214	2,254	2,352	2,447	2,626	2,952
0.4	0.2308	2485	2512	2533	2557	2,603	2,717	2,827	3,033	3,409
0.5	0.2884	2778	2808	2832	2859	2,911	3,038	3,160	3,391	3,812
0.6	0.3460	3043	3076	3102	3131	3,188	3,327	3,462	3,715	4,175
0.7	0.4037	3287	3323	3351	3383	3,445	3,595	3,740	4,013	4,510
0.75	0.4326	3402	3439	3468	3501	3,565	3,720	3,870	4,153	4,668
0.8	0.4614	3524	3552	3582	3616	3,682	3,843	3,997	4,290	4,821
0.9	0.5190	3728	3768	3800	3836	3,906	4,076	4,241	4,550	5,114
1.0	0.5768	3929	3971	4005	4043	4,117	4,296	4,470	4,796	5,390
1.25	0.7209	4393	4440	4478	4520	4,602	4,804	4,997	5,362	6,027
1.50	0.8650	4812	4864	4905	4952	5,042	5,262	5,474	5,874	6,602
1.75	1.0092	5197	5254	5298	5348	5,446	5,683	5,912	6,344	7,131
2.00	1.1535	5556	5616	5664	5718	5,822	6,076	6,320	6,783	7,624
2.25	1.2975	5892	5956	6007	6064	6,174	6,443	6,704	7,193	8,085
2.50	1.4418	6211	6278	6332	6392	6,508	6,792	7,066	7,582	8,523
2.75	1.5860	6514	6585	6641	6704	6,827	7,124	7,412	7,952	8,938
3.00	1.7300	6807	6879	6937	7003	7,130	7,440	7,742	8,307	9,336
4.00	2.3070	7857	7942	8010	8086	8,233	8,592	8,940	9,581	10,780
5.00	2.8840	8772	8867	8943	9027	9,192	9,593	9,980	10,710	12,037
6.00	3.4600	9623	9728	9810	9903	10,083	10,523	10,950	11,750	13,203

The location of the points on a traverse where readings should be taken is shown in Fig. 3. While theoretically four readings should be taken in the center zone, as a matter of fact the velocity over this area may be considered practically constant, and no appreciable error will be caused by taking only one reading at the center. The values in Table 2 are based on the above formulas for laying out a traverse and will be found very convenient for that purpose. As an example of its use assume that a traverse is to be made of a 24-in. pipe, twelve readings to be taken. One reading will be taken at $0.204 \times 24 = 4.9$ in. from the center of the pipe; one at $0.353 \times 24 = 8.46$ in. from the center; and one at $0.455 \times 24 = 10.92$ in. from the center.

TABLE 2. PIPE TRAVERSE FOR PITOT TUBE READINGS, DISTANCE FROM CENTER OF PIPE TO POINT OF READING IN PER CENT. OF PIPE DIAMETER

No. of Equal Areas in Traverse	No. of Readings	First R_1	Second R_2	Third R_3	Fourth R_4	Fifth R_5	Sixth R_6	Seventh R_7	Eighth R_8
3	12	20.4	35.3	45.5					
4	16	17.7	30.5	39.4	46.6				
5	20	15.5	27.2	35.3	41.7	47.4			
6	24	14.5	25.0	32.3	38.2	43.3	47.9		
7	28	13.4	23.1	29.9	35.3	40.1	44.3	48.2	
8	32	12.5	21.6	28.0	33.2	37.6	41.5	45.1	48.4

An example of laying out a traverse and finding the average velocity through a round duct is illustrated in Fig. 3, drawn from test results. Twelve readings were

taken, as shown on the diagram, the points being laid out according to Table 2. The velocities were then computed for each point and the average velocity for each area plotted as shown, the points on the lower and upper half of the plot being the same. A curve drawn through these points will indicate the velocity at the edge and at the center of the pipe, and these points should be used in calculating the average velocity.

❖

Circulation through Shunted Hot Water Radiators

By L. L. Brewster

Two common methods of installing the piping and radiators for a hot-water heating system are in common use in this country. In one the risers and return mains, of which there are several in various parts of the building, are run vertically and the connections to the radiating surface are made from the vertical riser and return pipes. In the other, usually a single pair of risers extend to nearly the full height of the building and on each floor a loop of piping is run around the entire floor as a branch from the riser, and connected to the return pipe. In this system the radiation is connected on each loop, as shown in Fig. 1. The loop itself is usually just under the floor, and radiator connections are taken through the floor to the radiators which are in the story above. The flow of water through the loop is from the riser around the loop and into the return, and almost always this pipe is of a uniform size throughout. At first glance it would seem that there would be no circulation of water whatever through the radiators and the riser, and the reason, therefore, is oftentimes obscure to many who do not stop to analyze the action which takes place.

Under average conditions the temperature of the water flowing into the loop is about 180 deg. F., and the temperature drop through the loop is rarely over 10 deg. F., and often as low as 5 deg. F. This, of course, means that a large volume of water is circulated. The pipe sizes should be so proportioned that the velocity of circulation is not over 10 ft., and good practice confines it to about 7 or 8 ft. per sec.

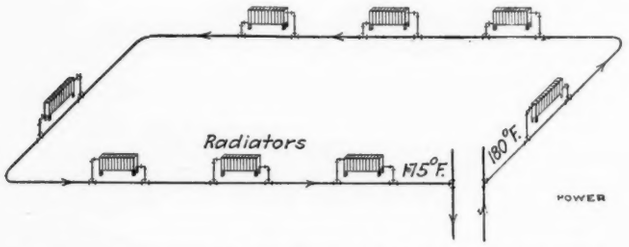


Fig. 1. Shunted Radiators of Hot-water System

The explanation of water circulation through the radiator can best be understood by reference to Fig. 2. In the first place, assume that the radiator is connected to the large tank (shown in dotted lines) of hot water at 180 deg. F., which is not in circulation, but which is maintained at about this temperature. With a room temperature of 70 deg. F. or less, there will be a temperature difference of 110 deg., which is quite sufficient to cool the water in the radiator enough to produce a distinct and positive difference of static head between the riser and return connections. In other words, there is a thermo-siphon action due to the cooling of the water in the radiator which produces a flow in exactly this same way and just as positively as in any hot-water heating system where the circulation is not forced, and also as in a great many cooling arrangements in use in connection with gas or gasoline engines. This circulation will continue just as long as there is a difference in temperature between the water in the radiator and that in the tank below.

If for the tank the pipe which constitutes the loop is substituted, the same action follows, even though the water in the loop may be moving at considerable velocity. The thermo-siphon effect which produces a circulation through each radiator is just as positive when the radiator is connected to the flow main, as if it were connected to a stationary tank or reservoir of water.

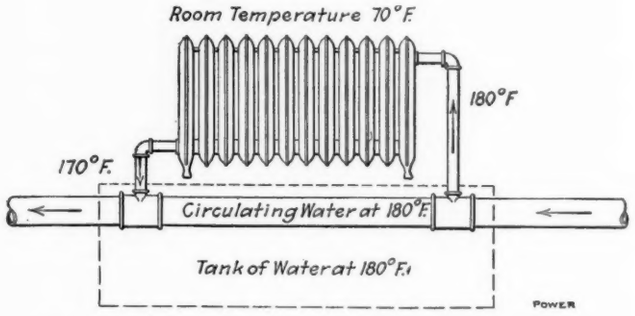


Fig. 2. Illustrating Flow through Radiator

It has been assumed and stated by some that the flow of water through the radiator is due to the fact that the path through the radiator is one of less resistance than that through the main, but this is not so. It matters not what the relative location of the flow main and radiator may be, or what the connections may be, except that one connection to the radiator should be made at a higher elevation than the other. Circulation will take place as long as there is a cooling effect which will decrease the temperature of the water in the radiator below that in the flow main.

In reality, the condition of flow through a single radiator or through any number of radiators considered individually, is brought about in exactly the same manner and is just as positive as the circulation of hot water in any hot-water heating system in which the water is not mechanically driven through the system of piping. The water in the flow main or loop may in this sense be considered a source of heat just as the hot-water heater in the complete system is, and in this case the radiator itself with its connecting piping is a circulating system which operates on the thermo-siphon principle.

[Some discussion of this problem would be of interest. What would happen if the radiator were below the main? Does the difference in head between the two connections to the radiator play no part in the action and what about the relative size of piping? Whether the system operates by gravity or has forced circulation will, of course, make a difference, and in the discussion the type of system should be specified.—Editor.]

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A well designed and operated furnace will burn many coals without smoke up to a certain number of pounds per hour, the rate varying with different coals, depending on their chemical composition. If more than this amount is burned, the efficiency will decrease and smoke will be made, owing to the lack of furnace capacity to supply air and mix gases.—"Practical Electricity and Engineering," Nov., '12.

EDITORIALS

Why Do Economizers Explode?

It is not often that an economizer explodes, but when one does the results are as disastrous to life and property as if occasioned by a boiler explosion.

Perhaps it is because so little has been published regarding economizer accidents that engineers have looked upon them as nothing more to be feared than a feed-water heater. Perhaps defects and weaknesses in economizers are considered of so little moment, viewed from the point of safety, that they are looked upon as commonplace, and not worth talking about, but is this true?

What causes an economizer to explode and what precaution should be taken to insure its safety in operation? Apparently there are several reasons why damage to the power plant may occur, some of which are occasioned by carelessness on the part of an attendant. For instance, an economizer may be cut out of service for cleaning or repairs. The gases from the boiler furnaces are bypassed to the chimney, and the feed water is shut off from the economizer. After repairs have been made there is a chance that the hot furnace gases may be turned through the economizer again without opening the valves in the inlet and outlet pipes. The water in the economizer would become heated, steam would be generated and an explosion from excessive pressure would occur.

Another possible cause of explosion is an accumulation of gases in the economizer after it has been cut out of service, due to a leaking damper. A lighted torch could ignite the gas, which might wreck the economizer.

If the economizer were cut out of service for any reason and the dampers leak, what is to prevent the water left in the tubes from generating steam to a pressure sufficient to explode the economizer? How much leakage of hot gases past the dampers would be necessary to produce this result?

Most economizers are so piped that the feed water is pumped from an open heater, through them to the boilers; the economizer would then be under boiler pressure. If a header or tube becomes weakened, the pressure may cause a rupture with serious results.

Suppose the firemen in the boiler room attend to the water level in the boilers they are operating and suppose the demand for steam decreases for a time, each fireman would naturally shut off the supply of feed water to his boilers, not by throttling the pump, but by closing the valve in the feed pipes, paying no attention to what the other firemen were doing. If the pump were not equipped with a regulator the pressure would build up in the economizer, if it is between the pump and the boiler, and most of them are. What happens? The pump continues to operate at its normal capacity, but as the discharge beyond the economizer has been throttled the pressure in the economizer becomes so excessive that the metal is ruptured, and the water at high temperature flashes into steam, producing a terrific explosion.

Such a condition could occur with each fireman working independent of the other. It might not happen in years of service, but if the firemen were not working together there would be such a danger.

Owing to the location and work done by economizers it is difficult to inspect them as thoroughly as a steam boiler, but it is just as necessary. Many interesting experiences with economizers could doubtless be related by engineers who have operated them, which, if published, would be of value in assisting others to prevent accidents from various causes. If any reader has had any such experience, we would welcome its account for publication.

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Be Neighborly

The custom among engineers of visiting other plants to look over the equipment and exchange ideas is good and should be encouraged. Some acquaintances thus made from what was intended as a casual visit develop into lasting and mutually helpful friendships. Seldom will a visit to a strange plant be made without some benefit being derived. Unfamiliar machinery is seen in operation and discussed, new and original methods of boiler and engine management are noticed, working conditions and wages may be talked over and comparisons drawn; all of which tend to establish a bond of fraternity in a vocation which is individually isolated.

As a rule, engineer visitors are cordially received and given every opportunity to enjoy and profit by their visits. Occasionally, however, the visitor is not admitted until he has been cross-examined as to his identity and the purpose of his visit in a way he may think uncalled for and resent. Offense at such a greeting should not be taken too quickly, as it is quite likely that the engineer is merely justifiably cautious, and the reserve, or possibly incivility, generally disappears when he is satisfied that the visitor has no ulterior motive.

Itinerent pedlars and, too frequently, agents for engineering supply houses are responsible for this caution on the part of the engineer. Instead of stating their business in a direct, straight-forward manner and leaving it to the engineer as to whether he is interested or can spare the time to discuss the matter, many agents adopt the subterfuge of being desirous of looking the plant over, and when it is believed that the engineer's attention can be compelled, samples are produced and the real object of the visit is disclosed. Naturally the engineer resents this thievery of his time, and consequently is suspicious of visitors and a bit chilly in his attitude toward them.

Another undesirable visitor who has done much to rub the "Welcome" off the power-plant mat is the bibulous engineer who has abundant leisure and intrudes in engine and boiler rooms while in a condition which cannot be tolerated. In the engineering vocation, as in other walks of life, a man is likely to be judged by the personal appearance and demeanor of the people he entertains.

As a class, engineers are broad-minded and affable; so one need not hesitate to ask admittance if he plainly states his purpose and his appearance is respectable.

The American Institute of Steam Boiler Inspectors

As the steam boiler is, and undoubtedly always will be the most vital part of power-plant equipment, any and all organized effort to better plant conditions and promote public safety by encouraging the building of better boilers and the exercise of greater care in their operation and upkeep is to be welcomed.

The American Institute of Steam Boiler Inspectors organized about two years ago is proving a factor for good in this direction. By exchanging ideas and experiences and listening to lectures dealing with every phase of boiler design, construction and operation, the boiler inspector becomes more valuable to society and his employer.

Much ado is made of the avoidable destruction of life and property by the country's industries. That is as it should be. It is strange that so little attention is paid by the general public to the destruction of life and property by the explosion of steam boilers. There is, on an average, one boiler explosion a day, each more or less destructive of life and property, and too often these losses are avoidable.

Besides learning how to do their own work better the work of the boiler inspectors' institute should be to combat this evil by promoting boiler legislation. Surely there are few organizations better qualified to draw up good boiler laws than the inspectors. To do their everyday work at all they must be specialized in finding defects and their causes and in recommending the proper use of defective boilers until the necessary repairs are made.

The institute will be glad to have the coöperation of engineers, boiler makers, designers, etc., and as all of its meetings are open ones, the plant engineer and others, by attending and participating in the discussions, not only can coöperate but can learn much that is valuable to them and which will aid them in performing their own work better. We wish success to the American Institute of Boiler Inspectors.

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The Divine Affirmative

Somewhere sometime we read something about something like that—and it made a deep impression. The gist of it was that the fellow that succeeds is he that asserts himself. When he gives orders, obedience is impulsive; there is no doubtful tone to the command and it is a foregone conclusion that what is asked simply must be done. Those receiving the instructions find themselves carrying them out before they have had time to raise any questions as to whether or not they can or should carry them out.

Perhaps this chap with the confident manner has no more—maybe less—ability than the timid, diffident apologetic man, but he gets higher up in the scale of life's successes by sheer force of his pugnacity.

The worst thing about this "divine affirmative" is its close relationship to a quality that is anything but divine, and hasn't such a polite name either—just plain "bluff."

How often we have heard someone referred to as a "bluff." He knows nothing, but he "chucks a bluff." Very often he "gets away with it." Far be it from us to commend this sort, on general principles, but we must give him credit for having discovered, consciously or unconsciously, the value of self-assertion. He may undeservedly succeed, if not permanently, for a time at least; and it is better to be a "has been" than a "never was." On the other hand, many a one with real merit never has attained the success he deserves and nine hundred and ninety-nine times out of a thousand, the explanation is the same, although variously characterized as "lack of push," "diffidence," "modesty," "inertia," "lack of self-confidence," etc. But it makes no difference what it is called; they are all one and the same thing.

These two types of men are prevalent and account for such apparent inconsistencies as the fool of his class now riding in his automobile while the honor man barely ekes out an existence. That the one succeeds, often in spite of lack of ability, and that the other fails, usually in spite of ability, is only a matter of psychology after all. It is instinct to trust, without question, the self-reliant man, to grant authority to him who assumes it and generally to make way for the forceful, masterful man. Equally is it natural to distrust without reason the hesitant man, to ignore the behests of him who cannot appropriate authority and make it a practice of pushing aside the man who offers no resistance.

Take pattern from the bluff, but beat him at his own game by being prepared to make good when tested, for, although the world stands aside while the "pusher" goes by, it examines him carefully from the rear and if he presumed without "having the goods" it trips him up before he gets far.

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The Central Station

If the running of many small industries from a central power plant is the social-economical thing to do it will be done and no blind opposition or senseless wriggling under the squeezing process will stop it.

But is it? If an individual owned any large city and everything in it, would he put in a single large power station and run everything from it, or would he have a multiplicity of small plants, one for each industry? Probably he would do neither. He would group neighborhood plants so as to get the economy of aggregation and the averaging effect of multiple demand, and to use the heat rejected by the engines for heating and other useful purposes.

There are many places where central-station current is logical, economical and the right thing to use. There are many places where it is a misfit and where it costs the customer much more than he could make it for, and very much more than he and his neighbors upon the same block could make it for, if they would put a power plant in one of the courts or cellars of the block and heat, light and drive the whole block from it, each tenant or user paying his proportionate share.

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One of the simplest pieces of apparatus used in the testing of power-plant equipment is also one of the least used—the pitot tube. Frank L. Busey has likely hit the true explanation of this in his account of its use in air measurements on page 156, where he says: "That it is not more extensively used is probably due to the fact that it is not more generally understood." He then proceeds to try to overcome this obstacle by explaining the instrument in very clear and simple language and indicates its wide field of usefulness.

READERS WITH SOMETHING TO SAY

Division of Expense in Isolated Plant

I have read with considerable interest different articles in POWER and other mechanical papers on the victories won by the isolated plant and also on the operation of such plants, but very few articles are accompanied with figures showing the division of expenses of all-year operation, showing what should be charged to the heating system if there were no engines and generators, and charging to the electrical output during the summer months everything except what would be needed to keep the place in operation if there was no plant.

I hope to see more on the subject and trust that the authors will give the data mentioned above.

C. WHITE.

St. Louis, Mo.

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Examination Questions

The following questions were asked an applicant for a first-class engineer's license in Massachusetts:

1. How would you put the spool in the center of the rod of a duplex pump (it having slipped) if there were no marks to guide you?
2. How would you get a piston off a duplex pump if you had tried a lead hammer on the end of the rod and it had proved unsuccessful?
3. How many steam ports are there in a duplex pump? Why?
4. What are compression valves for on a duplex pump?
5. Did you ever put a new set of snap rings in a solid piston of an engine?
6. What did you have to do to them before putting them in?
7. What diameter snap rings would you order for a 12-in. piston?
8. Supposing the rings were just cut across, how would you know, without figuring, just exactly how much to take out in one cut to bring a ring to the required size?
9. Did you ever take the piston out of an American Ball engine? What did you have to be very careful of when taking the piston out?
10. How did you put it back? How did you get it by the counterbore?
11. Did you ever have the valve of the American Ball engine out? What did it look like? How did you put it back again?
12. What peculiarity has the Ames engine? How would you change the lead without changing any of the moving parts or changing the position of the wheel and still have the lead equal on each end?
13. If you just took charge of a plant and you had a high-speed engine, how would you find out how much clearance you had on each end, there being no marks for striking points and no time to find them, and you had to start up in a few minutes?
14. Were you ever inside a B. & W. boiler? Where and how does the feed water come in? Where is the mud drum?
15. Show by a drawing how the tubes of a B. & W. boiler are placed with reference to the steam and water drum? Show where the baffles are placed in this boiler and the path taken by the gases.
16. Give two reasons for the tubes being inclined.
17. How are the tubes placed with reference to the drum of a Heine boiler? How much higher is the water in the rear end of a Heine boiler than in the front, the boiler being 18 ft. long?
18. What does the feed pipe of a B. & W. boiler pass through on the inside of the drum? How is it supported?
19. Where is the mud drum in a Heine boiler?
20. How would you get up to put a new fusible plug in a B. & W. boiler?
21. How would you get to the other side of the baffle-plate above the tubes?
22. What would you be very careful of in putting a new tube in the bottom row of a B. & W. boiler? How would you get the old one out? What kind of a cutter is used?
23. If you put a welded tube in, where would you put the weld?
24. What would you be particularly careful of in regard to the ends of the tubes?
25. How are the short nipples connecting the mud drum of a B. & W. boiler made tight? What does the tool look like that is used in the process?
26. If a man came from the boiler shop and expanded some new nipples in the mud drum of a B. & W. boiler, how would you know if the job would be tight before you started the boiler?
27. How is the B. & W. boiler supported?
28. How would you clean the soot from the back of the bridge-wall?
29. What care would you give the mud drum of a B. & W. boiler?
30. How is the Heine boiler supported?
31. Show by a sketch how the baffle-plates are placed in a Heine boiler and also show the travel of the gases.
32. How do the Heine stay-bolts differ from ordinary stay-bolts? Why are they hollow?
33. How are the plates put in a Heine boiler? Where are the handholes?
34. How would you clean out the mud drum of a Heine boiler if the blowoff to the mud drum got plugged up?
35. (Showing a safety valve in which the valve is not attached to the spindle.) Is this a Massachusetts standard valve? Why? If this valve had a blow-down ring, where would it be? If you wanted this valve to blow at 50 lb. higher pressure, what would you do?
36. Explain the advantages of superheated steam.
37. Does the Stirling boiler have straight tubes?

38. Show by drawing how the steam and water drums are connected in the Stirling boiler.

39. Show the path of the water circulation in this boiler.

40. What is a cross-box? How is it made? How is it attached to a boiler?

41. What shape are the holes cut in the drums of boilers having cross-boxes? Doesn't this weaken the boiler?

42. Why is it the Heine boiler has throat braces near this point, while the B. & W. has not?

43. Show how the Stirling boiler is supported.

44. How would you clean out the bottom drum?

45. Where does the feed water enter in the Stirling boiler?

46. Did you ever run the Rollins engine?

47. How do you equalize the cutoff on the Rollins engine?

48. How do you equalize the cutoff on the Putnam engine?

49. What is there on a Brown engine to equalize the cutoff? Does the Brown engine ever have a different method of adjustment? If so, describe it.

50. Of what material is the shell of a return-tubular boiler made? What material is used in the heads? What is the limit of the tensile strength for each?

51. Suppose you fitted a new snap ring to a piston of an engine, and the ring proved to be too narrow for the recess, and every time the engine took steam on that end, the incoming steam caused the loose ring to knock. What would you do to stop it without getting a new ring?

52. Did you ever run a condensing engine?

53. What kind of a condenser did it have?

54. With a jet condenser, how would you start the engine?

55. If you were called away from the engine room for twenty-five minutes and while you were gone a considerable load was thrown on the engine, how would you find things when you got back?

56. If you were carrying 28 in. of vacuum and lost it, how much would you have to increase the boiler pressure to carry the same load and cutoff at one-quarter stroke, the same as before losing the vacuum?

57. Is there any danger of getting water in the engine with a jet condenser? What do they do to prevent it? Do all jet condensers have vacuum breakers?

58. Is there any danger of water getting into the cylinder with a surface condenser? If so, why?

59. Is there any danger of water getting into the cylinder, with a siphon condenser?

60. Why does a siphon condenser require a tail pipe? How long is the tail pipe?

61. Do you require to pump the condensing water to a siphon condenser?

62. Did you ever run a siphon condenser?

63. If there were a small air leak about half way up the tail pipe, how would it affect the vacuum?

64. How many bolt holes are there in a 12-in. standard flange?

65. Can you change the cutoff of one steam valve of the Putnam engine, without changing the cutoff of both?

OLSEN M. JACKSON.

South Weymouth, Mass.

Notes on Portable Steam Engines

Portable self-contained steam units consisting of a locomotive-type boiler with an engine mounted on the barrel of the boiler, and the whole mounted upon wheels, are largely used for agricultural and construction purposes Such a method of construction is common both to the large traction engine for road haulage and the steam road roller. There are one or two unusual features concerning such steam units worthy of notice. The first is the special precautions necessary in setting the slide valves. It is obvious that such an engine having a hot boiler shell as a bed, requires rather different treatment to that accorded to the valves of an ordinary horizontal engine. If the valves are set carefully in the ordinary way, the efficiency of the plant and its consequent economy are seriously impaired. Many instances are known where an otherwise capable engineer has failed to take the boiler expansion into account and then has been sorely puzzled at the alarming increase in coal consumption after overhauling the engine.

There is, of course, only one way to do the job, and that is after thorough overhauling and elimination of slack due to wear, to leave the slide-chest covers off, and raise steam in the boiler. As much as ⅛ in. is quite an ordinary extension in length of the portion of the shell serving as the engine bed. This error in setting small valves makes a considerable difference in the results. The expansion also alters piston clearances. Total clearance should be allowed at the front or the crank end of the cylinder if adjustment is made cold. The expansion of the boiler then provides ⅛-in. clearance under cover.

Usually the trouble is caused by the ordinary conditions of overhauling. The responsible mechanic, who it must be remembered has nothing to do with the engine under steam, having opened up the cylinder, assumes the valves are improperly set and follows the usual practice of centering the cranks and splitting valve lead at each end of the stroke.

When the steam is on the boiler, as already detailed, the setting becomes so faulty that the engine is troublesome to handle, lead being doubled at one end of the stroke and "blind" at the other. Another disadvantage results from the juxtaposition of hot boiler shell and engine. The bearings are always warm. This fact makes the provision of a good lubricating oil of high viscosity imperative, ordinary engine lubricating oil being too light.

A. L. HAAS.

London, England.

Diagrams of Cross Compound Engine Wanted

The writer is desirous of studying conditions of valve adjustment for best results in running a Corliss cross-compound condensing engine and would be glad to receive diagrams from some brother engineer taken from such an engine, driving full load, when running condensing and when running noncondensing, with valves set for only enough compression for quiet running when running condensing. The main object is to note the difference in compression when running the engine under the conditions stated.

L. G. BORDEN.

Wharton, Tex.

QUESTIONS BEFORE THE HOUSE

The Value of the Horsepower

Referring to my article on horsepower, Jan 28 issue, I find that the conversion table on page 71 of Marks & Davis' "Steam Tables and Diagrams" gives

1 hp. = 550* ft.-lb. per sec.
1 hp. = 0.7457 kw.
1 cheval-vapeur, or Pferdekraft, or "continental horsepower" is 75-kg.-meters per sec.
1 hp. = 1.0139 chev.-vap. = 0.7604 poncelet.
1 poncelet = 100 kg.-meters per sec.
1 ft.-lb. = 3.7662×10^{4} watt-hours = 32.174 ft.-poundals.

These figures correspond exactly to the ones I gave. Marks & Davis' tables are generally accepted as standard by American engineers. The horsepower thus represents "the same amount of power at different places," and its relation to the watt is a definite number (see Circular No. 34, page 11)

$$1\ hp. = 745.7\ watts$$

WILLIAM KENT.

New York City.

Cooling Pond of Crescent Plant

The test report of the performance of the power plant at Wampum, Penn., with reference to the impounded reservoir for condensing purposes, in the issue of Dec. 3 was read with interest. It was my pleasure to visit this plant while it was in operation on several occasions during the last two years. I have come to the conclusion that it is the worst arrangement for a hot-water cooler that I have ever seen. This reservoir is certainly large enough (about 6½ acres), the trouble is that there is practically no movement to the water, the surface being as placid as a plate of glass. The condensate flows into this reservoir at one end and is drawn out near the other end with a total fall of about one foot, and as the weather becomes warm in the early summer the entire volume warms up and remains hot until the cold weather comes on again.

I most certainly disagree with the engineers who designed this plant that the reservoir will cool the water of condensation sufficiently. My observation leads me to the conclusion that it is practically impossible to provide a reservoir of this design of sufficient capacity to maintain a low temperature during the entire summer.

A casual glance over the report submitted tells the story. This is a modern power plant and yet the injection water is so hot that the best vacuum possible is 22 in. with the barometer at 30 in. and the barometer stands like this for nearly four months of the year. A well designed spray system must be added to distribute the hot water to produce a modern economical condensing plant.

As most of us know, a portland-cement mill is kept in operation day and night for usually about ten months in the year, being only shut down during severely cold weather, just when this reservoir would be most effective. But with the addition of a properly designed cooling system, it would be very successful in keeping the water cool during the summer season when the mill is run continuously night and day.

CHARLES W. WILSON.

New Castle, Penn.

*Exact value by definition.

Dalton's Law in the Steam Plant

In the article under the above title, appearing in the issue of Dec. 31, the author discusses the flash point of an oil, as an illustration of the application of Dalton's law. He endeavors to show the error in the common idea that the flash point will be made higher by heating the oil in an atmosphere of steam or air under 150 lb. pressure, and states, "Now the flash point, or the temperature at which ignitable vapors are given off, of most steam-engine cylinder oils is usually between 500 and 600 deg. F. They evidently then have to be heated to this temperature before their vapor pressure equals that of atmosphere, so that at 366 deg. F. (temperature corresponding to 150 lb. steam pressure) their vapor pressure must be quite low and the 150 lb. steam (a different gas) pressure can have no deterent effect on the formation of the oil vapor. If the oil were tested in a closed room where the air pressure is 150 lb., the same flash point would result."

The above statement is inaccurate and quite misleading, and as the question of the flashing of an oil is commercially important, though often misunderstood, it is worth while to find in just what way Dalton's law becomes applicable to a case of this kind, where an explosive mixture is formed.

Consider first the simple case of an open pot containing a liquid, with atmospheric air above. Whatever the liquid there is always some tendency toward vaporization, and there is always, therefore, some vapor present and mixed with the air above the liquid. Not only that, but there is a quantitative relation between the weight of air and weight of vapor present. As was rightly pointed out in the article referred to, vaporization occurs until a certain known maximum vapor pressure is reached, which is dependent solely on the temperature. Now, since the total pressure of the vapor-air mixture is the barometric pressure, and since both vapor and air fill the volume and exert their own pressure, it is not difficult to show that the following relation holds true:

$$\frac{Weight\ of\ vapor}{Weight\ of\ air} = \frac{pressure\ of\ vapor}{pressure\ of\ air} \times \frac{density\ of\ vapor}{density\ of\ air}$$

in which both densities are taken at atmospheric pressure. In the above equation the pressure of the air will be the barometric pressure minus the vapor pressure.

This quantitative relation must be kept strongly in mind, because it shows that for every pound of air above a liquid at a given temperature there is a definite frac-

tion of a pound of vapor mixed with it. If the total pressure were anything other than barometric, the same relation would hold, except that the air pressure would now be total pressure minus vapor pressure.

It is obvious that if the air above a liquid is kept in continuous circulation, vaporization will go on continuously so as to always maintain the proper proportion. From experience it is known that this does occur provided the heat necessary for vaporization can be supplied to keep the temperature from falling. Assume an oil in an open pot being heated slowly by a flame applied underneath, so that the temperature changes are gradual. Vaporization occurs at each temperature until the gas mixture above the oil is composed of air and oil vapor in the proportions determined by the equation given previously. If early in the test a lighted taper be applied above the pot, ignition will not occur, because the ratio of oil vapor to air does not represent an explosive mixture; in other words, the mixture is too lean to take fire, even though the taper is at a temperature higher than that at which ignition would occur.

As the temperature of the oil is increased, however, its vapor pressure becomes greater and as may be readily seen from the equation the gas mixture becomes richer until explosive proportions are reached, and the oil will flash. Flashing simply is the instantaneous bursting into flame and extinction of the gas mixture above the oil. The reason that the entire mass does not burn is that vaporization must always precede burning, and that by the time the liquid just below the ignited vapor has received heat enough to vaporize and form igniting proportions, the temperature is too low for ignition.

If more heat is applied below the pot and the temperature increased still further, there will be igniting proportions continuously, but it may be necessary to go 30 or 40 deg. further before reaching the burning point. At this point the liquid receives heat enough from the ignition to vaporize and form igniting proportions before the temperature has dropped below the ignition point, and the whole mass bursts into flame.

Finally, consider the case of the oil under a pressure of 150 lb. If this is steam pressure and there is no air present, the oil can never flash whatever the temperature, because there is no air to burn it. However, the vaporization will occur in accordance with the equation given. On the other hand, if it is air pressure, and say that the flash-point test is being made in a room where the air pressure is 150 lb., then the flash temperature will be materially changed, due to the high pressure.

At any temperature the proportion will apply that

$$\frac{\textit{Weight of vapor}}{\textit{Weight of air}} = \frac{\textit{vapor pressure}}{150\ \textit{lb.} - \textit{vapor pressure}} \times \frac{\textit{density of vapor}}{\textit{density of air}}$$

It needs little consideration to see that at a given temperature the gas mixture above the pot will be much leaner with the total pressure 150 lb. than with the total pressure barometric. In other words, the vapor pressure is now a much smaller fraction of the total pressure, so that the weight of vapor is a much smaller fraction of air. Consequently, the temperature will have to be considerably increased before explosive proportions are reached, which means that the flash point is considerably higher.

New York City. LOUIS GROSSBAUM.

The Logical Unit of Power

The editorial under the above caption in POWER of Dec. 3, 1912, led me to secure circular No. 34, of the Bureau of Standards, on "relation of horsepower to kilowatt."

It may be of interest to look into the accuracy of the kilowatt a little. In the table given by the Bureau of Standards, the lowest equivalent is 745.6 watts, the highest 746 watts, a variation of four parts in 7460, or one part in 1865. It is improbable that the ampere is known within one part in 10,000, although the recent work of Smith and Mather may have determined it more closely. The true ohm is probably not known within three parts in 7500, or one in 2500; the present international ohm is reproducible within about one part in 50,000, but there is little work done with an accuracy of over five parts in 7500. The volt, of course, is known only within the combined accuracy of the ohm and ampere determinations already made. What is the accuracy of the ordinary electrical measuring apparatus in commercial use? Probably one part in 1000.

What then is the effect upon the operating engineer of Circular 34? Apparently only to give him the momentous information that the Bureau of Standards will hereafter do what he has already been doing, divide kilowatts by 0.746 to get horsepower.

Is the statement in the editorial correct, that the kilowatt is based on physical phenomena which have the same value at all points within man's reach? I was under the impression that in the ultimate analysis, the ampere had to be determined by the ampere balance, which depends upon gravity, and the determination of g, for its accuracy.

DONALD M. LIDDELL.

Elizabeth, N. J.

Condensers for Lubricator

Relative to the repair to a lubricator condenser, as described in the Jan. 7 issue, I submit the following:

The main object of a lubricator condenser is to insure a more constant level, or head, of water working on the lubricator. The lubricator depends upon this water head for its operation. Therefore, it is apparent, that to obtain a constant flow of oil, the water level must be maintained constant. The same amount of water could be stored in a straight pipe, if it were long enough, as can be stored in the bulb-form condenser, but when the demand for oil is greater than normal, the head of water, which is causing the flow of oil, is considerably altered. This results in a decreased flow of oil unless the setting of the needle valve governing the feed oil is changed. Should this valve setting be altered, the flow will gradually increase as the water rises again in the pipe, for when the water falls the condensing surface increases and consequently a greater supply of water follows.

To guard against this continual fluctuation, the condenser has been added, which, because of its greater horizontal cross-section, allows of a certain demand for water, with a very slight variation in head.

Fort Flagler, Wash. J. M. Row.

INQUIRIES OF GENERAL INTEREST

Zinc in the Return Tank—Will zinc placed in the return tank keep the boiler from pitting just as well as when placed in the boiler?

I. M.

Zinc in the return tank would have no appreciable effect.

Position of Blow-off Valve and Cock—When a valve and cock are used on a boiler, which should be placed next the boiler? Which should be opened first when the boiler is blown off.

G. B. L.

The cock should be placed next to the boiler. In blowing off the boiler, the valve should be opened first, thus preventing the whole pressure from coming on the valve.

Water Required to Condense 40,000 lb. of Steam Per Hour—When using a surface condenser, how much water will be required to condense 40,000 lb. of steam per hour?

G. S.

Where the condenser is clean and tight, 600,000 lb. per hour will be sufficient. As, under ordinary operating conditions, the condenser and the piping will not remain clean and tight, provision should be made for at least 800,000 lb., or 96,000 gal., of water per hour at a temperature of 70 deg. F.

Relation of Piston Displacement to Volume of Water—What relation should the piston displacement of a pump bear to the volume of water which is to be pumped for a jet condenser at full load?

P. J. F.

Surface water under atmospheric pressure ordinarily contains 2 to 12 per cent. of air by volume. To provide for the presence of air, the leakage of air and other causes of pump slippage, a very liberal factor is usually allowed, an average figure being about 20 per cent. excess capacity.

Preventing Rust from Salt Water—What is the best way to keep pipes and iron work from rusting when exposed to the action of salt water?

F. J. R.

The best method is to thoroughly clean the iron work, paint it with red lead and then give the work a coat of hot asphalt paint. Steel pipe and iron work which are made from impure material are most inclined to rust in the presence of salt water, the oxidation being likely to break through almost any kind of coating. Usually, this may be prevented by giving the material a coating of something which will exclude the moisture of the atmosphere as much as possible.

To Determine Boiler Water Evaporation—How is the amount of water evaporated by a boiler determined?

M. C.

The amount is best found by weighing the feed water for a period of at least 10 hr. A shorter test may be made, but it would not be so accurate. Dividing the number of pounds of water by the number of hours would give the amount of water evaporated per hour. In making such a test care should be taken that all of the water fed is weighed and that all of the water credited to the boiler be fed to the boiler and evaporated into steam. All leaks from blowoff valves, etc., should be stopped before the test or accurately accounted for.

Preventing Oil Running on Shaft—How can oil be stopped from running along a shaft from a bearing or other point where it is in contact with the shaft?

C. H. W.

Mount a sharp-edged disk on the shaft that the oil may be driven off the disk by centrifugal force. It is customary under such circumstances to surround the disk with a shield for catching and draining off the oil. Another method is to use a wiper wick of fibrous material; it will rub on the shaft and wipe off the oil. Such a wiper has to be occasionally renewed and kept clean to prevent the rubbing surface of the wiper from becoming saturated with oil.

Fluctuating Gages—In a 15-ton refrigerating plant, why should the gages registering the suction and condenser pressures fluctuate continually and the suction gage sometimes stick?

W. B.

If there is no valve in the pipe connections to the gages, the hands are sure to fluctuate due to the variation in pressure during suction and discharge. The usual practice is to have a valve in the line connecting the gages, so that they may be throttled down to a point where the fluctuation is not greater than 2 lb. The operator must be careful, of course, not to close the valve entirely, although this would be at once indicated by the pointer dropping back to zero. The sticking of the gage is due to some mechanical defect which a careful inspection should reveal.

Radius Curve of Reverse Link—To what radius should the reverse link of a double eccentric reversible D-slide valve engine be curved, that is, to what part of the engine should this curve be proportioned?

W. A. M.

When the rocker arm has no backset, the correct radius of a link should be equal to the distance on a horizontal line from the center of the main shaft to the center of the rocker box. If the rocker has any backset, subtract the amount of backset from this length. Some locomotive manufacturers make the link radius ¾ in. per ft. less than the above, but the distance given is the correct one and has been so accepted by the Railroad Master Mechanics Association.

Collapsing Strength of Iron Flues and Cylinders—What will be the collapsing strength of a cylindrical iron tank 50 ft. long and 50 in. in diameter made of ¼-in. iron?

J. W. D.

Fairbairn's formula for the collapsing strength of iron cylinders is

$$p = 9{,}675{,}600\,\frac{t^2}{ld}$$

in which

p = Pressure in pounds,
t = Thickness in inches,
l = Length of cylinder in inches,
d = Diameter of cylinder in inches.

Substituting the values given

$$p = \frac{9{,}675{,}600 \times (0.25 \times 0.25)}{(50 \times 12) \times 50} = 20.1575 \text{ lb.}$$

Cost of Water Heating with Live Steam—What would it cost to heat 25,000,000 gal. of water from 55 deg. to an average temperature of 185 deg. F. with live steam at 75-lb. pressure, coal costing $4.40 per long ton, 1 lb. to evaporate 11 lb. of water?

W. J. W.

With an initial temperature of 55 deg., to heat a pound of water to 185 deg. will require

$$185 - 55 = 130 \text{ B.t.u.}$$

As a gallon of water weighs 8⅓ lb.,

$$8.33 \times 25{,}000{,}000 = 208{,}250{,}000 \text{ lb.}$$

will be the total weight of water. As each pound requires 130 B.t.u.,

$$208{,}250{,}000 \times 130 = 27{,}072{,}500{,}000 \text{ Bt.u.}$$

will be necessary to heat the water. The heat in a pound of steam at 75-lb. gage pressure, above 32 deg. F., is 1184.4 B.t.u. Assuming that steam is discharging from the heating coil at 185 deg., there will be available to heat the water in each pound of steam

$$1184.4 - 153 = 1031.4 \text{ B.t.u.}$$

Then

$$27{,}072{,}500{,}000 \div 1031.4 = 26{,}248{,}303 \text{ lb.}$$

of steam will be required in all. As the evaporation is 11 lb. of water per pound of coal,

$$26{,}248{,}303 \div 11 = 2{,}386{,}209 \text{ lb.}$$

of coal will be needed, or

$$2{,}386{,}209 \div 2240 = 1065.27 \text{ long tons}$$

of coal, which, at $4.40 per ton, will cost

$$1065.27 \times 4.40 = \$4687.19.$$

Some heat will be lost in transmission and from radiation, so that more steam will be needed, making the total cost close to $5000.

ENGINEERS' STUDY COURSE

Formulas

The average rule, when expressed in words, is lengthy and, worst of all, hard to remember. Therefore, the *formula* is used to express mathematical relations and operations. As a formula is an algebraical expression of a rule, letters and symbols are used instead of words.

Take the rule for finding the indicated horsepower of an engine:

Find the continued product of the mean effective pressure in pounds per square inch, the length of stroke in feet, the area of the piston in square inches, and the number of strokes per minute; divide the product by 33,000.

As many know, this rule can be expressed as

$$Hp. = \frac{P \times L \times A \times N}{33{,}000}$$

Where

Hp = Horsepower;
P = Mean effective pressure;
L = Length of stroke in feet;
A = Area of piston in square inches;
N = Number of strokes per minute.

As multiplication signs are not necessary between letters in formulas, this horsepower formula may be shortened:

$$Hp. = \frac{PLAN}{33{,}000}$$

To indicate that quantities are to be multiplied we omit the multiplication sign and set close together the letters which represent these quantities.

Signs of Aggregation or Grouping

In formulas we use nearly all of the same signs that are used in arithmetic. The signs of *aggregation* are most important, as they guide us in the successive steps to be taken in performing calculations.

The signs are: the *parenthesis* ( ), *brackets* [ ], *vinculum* $\overline{\quad}$ and *brace* { }. If we wish to indicate the square root of 786 ÷ 3 we would express it thus:

$$\sqrt{786 \div 3} \text{ or } \sqrt{\frac{786}{3}}$$

The old radical sign was $\sqrt{\ }$, but now this sign and the vinculum combined make the radical sign. The parenthesis is the sign most used when only one sign of aggregation is required, although the vinculum may be used for the same purpose.

When only two signs of aggregation are required the parenthesis and brackets are used.

Example: $[(40 - 20) \div 5] \times 20 = 80$

Here the difference between 40 and 20 is to be divided by 5 and the quotient multiplied by 20.

When three signs are required the parenthesis, brackets and brace are used.

Example: $\{[(40 - 20) \div 5] \times 20\} - 4 = 76$

Here the difference between 40 and 20 is to be divided by 5, the quotient multiplied by 20 and 4 subtracted from the product.

Where an example calls for all four signs, the vinculum is used so that a parenthesis will not have to be inclosed within a parenthesis.

Example: $\{[(\overline{40 - 20} \div 2) \times 6 - 15] \div 4\} \times 20 = 225$.

Notice that the difference between 40 and 20 is to be divided by 2. The rest of the example is easily understood. All these signs of aggregation are frequently used in formulas and the student should familiarize himself with them.

As letters are used in formulas to designate quantities, it is customary to use the first letter of a quantity to identify it. Thus, in the horsepower formula we have *pressure, length, area* and *number* of strokes per minute, and these quantities are designated P, L, A, N respectively. We usually use V for volume, P for pressure, h for height, g for gravity or the constant acceleration due to the attraction of the earth, etc. This manner of designating quantities is not always done, however, so it is usually best to state below the formula what each letter represents.

In formulas where we have different pressures and volumes to deal with, we cannot use the same kind of letter for all the different pressures, volumes or whatever it is we are dealing with. To distinguish each of the different values of the same quantity we use what is called *primes* and *subs*.

A prime is a mark like a comma, and is placed above and to the right of a letter, thus P', p' or V', v'. The capital letters, P and V in this case, are read P' *major prime*, V' *major prime;* the small letters are read p' *prime* and v' *prime*. Thus we can easily designate, say, boiler pressure, initial pressure and terminal pressure by calling P the boiler pressure, p the initial pressure and p' (p' prime) the terminal pressure. This same manner of designation is applicable for all letters and quantities.

Subs are small numbers placed at the right and below the letters, thus, P_1, p_1 or V_1, v_1. They are read P *major* "sub 1," etc.

If the sub is 2 or 3, etc., the letter is read "sub one" or "sub two," etc. Arabic numbers (1, 2, 3, etc.) should never be used for primes, as the numbers are likely to be taken for exponents.

The student must learn to distinguish between a coefficient and an exponent, thus in the expression $3(bc)^2$. Here 3 is the *coefficient* and 2 is the exponent. Notice that *the cofficient denotes how many times a quantity is taken. The exponent indicates to what power the quantity is to be raised.* Thus in the above expression, the square of the product $b \times c$ is to be multiplied by 3.

In formulas we deal with *equations* and an equation is simply a statement that two expressions have the same value, i.e., they are equal to each other. Thus in the horsepower formula

$$Hp. = \frac{PLAN}{33{,}000}$$

notice that all to the left of the equality sign is of the same value as all to the right, i.e., the continued product of P, L, A and N divided by 33,000 is equal to the horsepower.

Suppose we apply this formula to an 18x42-in. engine running at 80 r.p.m. with 60-lb. m.e.p.

$$Hp. = \frac{PLAN}{33{,}000} = 259.64$$

The student should work out the above example.

We can make a number of equations out of this formula. When we do this we *solve* the formula for each of the values (letters) in terms of the others. Letting the formula apply to the same engine as in the above example, we will solve it for each letter in terms of the others.

$$P = \frac{33{,}000\,Hp.}{LAN} = 60\ lb. = m.e.p.$$

$$A = \frac{33{,}000\,Hp.}{PLN} = 255\ sq.in. = area\ of\ piston$$

$$L = \frac{33{,}000\,Hp.}{PAN} = 3.5\ ft. = length\ of\ stroke$$

$$N = \frac{33{,}000\,Hp.}{PLA} = 160 = number\ of\ strokes = 80\ r.p.m.$$

You will notice that when numerical values are substituted for the letters, the multiplication sign is used.

The segment of a circle is a part of the circle separated from the other part by a straight line.

The formula for finding the area of the segment of a circle when the segment is equal to or less than a semicircle is

$$A = \frac{4\,h^2}{3}\sqrt{\frac{D}{h} - 0.608}$$

in which

D = Diameter of the circle;

h = Height of segment, i.e., the greatest perpendicular distance between the circumference and and the chord or straight line;

0.608 = Constant.

Example: Find the area of the segment of a circle 75 in. in diameter, height of segment 25 in.

Substituting numerical values for the letters we have

$$A = \frac{4 \times 25^2}{3} \times \sqrt{\frac{75}{25} - 0.608} =$$

$$\frac{2500}{3} \times \sqrt{3 - 0.608} = \frac{2500}{3} \times \sqrt{2.392} =$$

$$833.3 \times 1.546 = 1288.43\ sq.in.$$

as the area.

As an example of formula where subs are used the following is given:

To calculate the amount of water required for a surface condenser the formula below is used.

$$W = \frac{H - t_1 + 32}{t_2 - t_3}$$

in which

H = Total heat of 1 lb. exhaust steam above 32 deg. F.;

t_1 = Temperature of condensate;

t_2 = Temperature of discharge water;

t_3 = Temperature of circulating water;

W = Pounds of circulating water required to condense 1 lb. of steam.

Example: How many pounds of circulating water are necessary to condense one pound of steam if the inlet water temperature is 60 deg. F., outlet 90 deg. F., hotwell temperature 101 deg. vacuum to be 28 in.? Here

H = 1104.1 B.t.u. (found from the steam tables);

t_1 = 101 deg. F.;

t_2 = 90 deg. F.;

t_3 = 60 deg. F.

Substituting, we have

$$W = \frac{1104 - 101 + 32}{90 - 60} = 34.5\ lb.$$

This shows a ratio of 34.5 lb. water to 1 lb. of steam.

The Massachusetts formula for area of safety valves is

$$A = \frac{W \times 70 \times 11}{P}$$

A = Area of valve in square inches for each square foot of grate surface;

W = Pounds of water evaporated per second per square foot of grate surface;

P = Absolute pressure per square inch at which valve is to open or blow.

Example: With a grate area of 30 sq.ft. and a combustion rate of 20 lb. of coal per sq.ft. of grate surface per hour, an evaporation of 10 lb. of water per pound of coal and with 100-lb. gage pressure, what size safety valve is required?

$$30 \times 20 = 600\ lb.$$

coal burned per hour.

$$600 \times 10 = 6000\ lb.$$

water evaporated per hour.

$$\frac{6000}{3600} = 1.67\ lb.$$

water evaporated per second.

$$1.67 \div 30 = 0.5567\ lb.$$

water evaporated per square foot grate per second.

Applying the formula

$$A = \frac{0.5567 \times 70 \times 11}{115} = 3.728\ sq.in.$$

The commercial size valve would be 2½ in.

A symbol frequently used in formulas is π, which is a Greek letter pronounced "Pi." The value of π is 3.1416, which is the ratio of the circumference to the diameter of a circle. Thus we have for the circle

$$C = D\pi$$

$$D = \frac{C}{\pi}$$

where

C = Circumference;

D = Diameter.

The Royal Society of Edinburgh is forming a provisional committee to consider how the tercentenary of the discovery of logarithms may best be celebrated. The year for this celebration will be 1914, as it was in 1614 that John Napier's "De Mirifici Logarithmorum Canonis Descriptio" appeared, although, according to Kepler, Napier had indicated his acquaintance with the properties of logarithms as early as 1594, in a letter to Tycho Brahe. Napier's logarithms were, of course, based on the sum of the series

$$1 + \frac{1}{1} + \frac{1}{1.2} + \frac{1}{1.2.3} + \cdots \frac{1}{1.2.3 \ldots \infty}$$

approximately equal to 2.718281828. It was not until 1624 that Briggs published his "Arithmetica Logarithmica," using the base 10. The appearance of Napier's "De Descriptio," supplemented by his posthumous, "De Mirifici Canonis Constructio" (1617), may be considered as an event but little less important than Newton's "Principia." John Napier was born in Merchiston, near Edinburgh, in 1550, and died there Apr. 4, 1617.—"Engineering and Mining Journal."

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Thomas A. Edison is too busy inventing to waste his time having medals pinned on him, so Mrs. Edison accepted the Rathenau medal from the Museum of Safety. This sounds like real modesty.

Mr. Andrew Carnegie was also present—and spoke. The daily press relates a story that Mr. Carnegie did not seem to recognize the building. "Why this," said Mr. Williams, "is your own building, built by you for the benefit of the United Engineering Societies." Then Mr. Carnegie retold it to the audience. Some more modesty!

(John Powers bold to us confess'd
He'd cast these lines from off his chest,
Feeling sure that we would need 'em
For our readers. Readers, read 'em!)

TO THE CHIEF
By John Powers

John and I, your two best men, are trying very hard to learn
How to heat these mills up nights with some coal that will not burn.
We keep hustling all the time—we are always on the jump—
But the little steam we get will just run the smallest pump.
If you say it can be done, we will try to be content.
And we'll keep right on afiring with asbestos and cement!

Good old Mister Efficiency has in his perambulations got a half-nelson on the garbage can. He now knows how long it takes to raise it, lower it, dump it—all done by employing the stop-watch to get the exact seconds. This valuable information has been compiled by the Chicago Public Service Commission—real garbage being used in the test. Here in New York there is record of several unofficial garbage tests, mainly to find out how long it will be before it is emptied. And if Hi Costofliving is not soon swatted beyond resuscitation, we won't be able to afford the luxury of garbage.

Confidence and esprit de corps are tremendously valuable assets to any organization.—"Engineering Record." According to our tell, some kinds of confidence people will bear watching. Our dragnet is still out for the corpse of that guy D. Esprit. If anybody in the neighborhood has observed Esprit, tell Kelly about it.

If you can find the humorous side of your worries there is lots of fun ahead of you, says "Wood-worker." Same thing about getting mad (or angry). Who the deuce cares? Laugh at yourself and get some fun out of it. Humor is Father Time's one big hint to longevity.

This is a true story. Once upon a time a Jersey fireman took a civil-service examination in the hope of being placed on the list of eligibles. The examiner regarded him with favor and asked if he would care to go to Overlook, an insane asylum maintaining its own power plant.

"But I'd have to be examined first, wouldn't I?" said the fireman.

"Well, I am the examiner."

"I know you are, but you're not a physician, are you?"

A writer in a machinists' paper says a machinist went to work in a shop as a lathe-hand, and for several days did not know the name of the firm, neither did he like to awsk. Now mark the subtlety, the perspicacity, of this master mind. The third day he glawnced up from his machine and—what do you think?—he saw the firm-name on the ashcan! But suppose some blighter had pinched the ashcan! My word, Watson, I'll work up this case myself.

It leaks out that Sir Joseph John Thomson has discovered a new gas, though he claims no importance for it. Quite so, Sir Joseph. The important thing is to discover a new gas meter, our present one being harder to beat than a hard-boiled egg.

Taking advantage of the parcels post, a well-intentioned individual sent us a 11-lb. hunk of exploded boiler as a souvenir. If this is trying to get hunk with us, we acknowledge the hunk. What we think is nothing to what the postman said when he brought it. Perhaps the w. i. i. has mixed our home address with that of the foundry down stairs.

Power Plant Chemical Laboratory Practice*

This report deals with the testing of only the chief materials used in power work, namely, coal, water and oil.

A list of questions was sent to 91 electric-railway companies. These questions were designed to bring out the extensiveness of the present use of the chemical laboratory in power work; the methods followed in laboratories at present in operation, and the materials tested.

The methods employed by five different companies are described in the report. Following is one of these descriptions:

METHOD EMPLOYED BY UNITED RAILWAYS CO., ST. LOUIS

The following apparatus is required for making a proximate analysis:

Balance, sensitive to 0.1 milligram	$65.00
Weights, analytical—50 grams to 1 milligram	15.00
Platinum crucible with cover, 0.8 gram	15.00
Iron ring stand	0.75
Bunsen burner and tube	0.50
Oxygen cylinder	20.00
Desiccator with porcelain plate	2.00
Parr calorimeter, electric ignition	75.00
Motor for calorimeter	5.00
Drying oven	7.50
Extra rubber and glass tubing, tongs, sample bottles, etc	5.00
Sieve with cover, 100 mesh	2.50
Steel mortar	2.00
Braun Chipmunk crusher	60.00
Pulverizer	25.00
	300.25

The following apparatus is required for making the sulphur determination:

Two beakers, 300 c.c	$0.50
Two watch glasses	0.25
Two funnels	0.50
Quantitive filters 11 cm Stirring rods 10 per cent. Ba Cl_2 solution Concentrated hydrochloric acid Weak solution $AgNO_3$	5.00
Sulphur photometer (Parr)	35.00
	$41.25

Three samples are taken from each car shipment to determine the proximate analysis for the amount of moisture, volatile matter, fixed carbon and ash.

Moisture—A 10-gram platinum crucible is weighed, putting the lid on the pan and placing the crucible on it. A 1-gram weight is placed on the weight pan of the balance and the coal sample is then added or taken from the open crucible until the balance is in equilibrium, thus introducing and weighing the 1-gram sample used for the approximate analysis.

The crucible containing the weighed sample of coal is placed in an air oven with the cover off, and allowed to remain one hour, the temperature of the oven being kept at 105 to 110 deg. C.

The crucible is removed after remaining in the oven an hour, put into a desiccator over concentrated sulphuric acid, allowed to cool for a few minutes and then weighed. The difference in weight between the first and second weights equals the moisture.

Volatile Matter—After determining the moisture the crucible containing the dry coal is put on a clay triangle so placed that the crucible will be 6 to 8 cm. above the top of a bunsen burner. The burner is adjusted so that it gives a flame about 20 cm. high, and is placed under the crucible so that the flames envelop the crucible and the latter is thus heated for 7 min. in a place free from drafts. (Any carbon collecting on the outside of the crucible should be burned off.) After cooling the crucible is

*Excerpts of "Appendix B" of report of Committee on Power Generation presented at the convention of the American Electric Railway Engineering Association, Oct. 7 to 11, 1912.

weighed, and the difference between second and third weights equals the volatile matter.

Fixed Carbon and Ash—The crucible containing the remaining material from the determination of volatile matter is heated until the coke is red hot at the edge. Then a slow stream of oxygen gas from the tank is passed into the crucible through a small metal or glass nozzle until all carbonaceous matter is burned. The oxygen must be used very carefully or mechanical loss will result from small ash particles being thrown from the crucible. As a test of complete combustion the crucible is reheated and oxygen again passed into it. The crucible is then cooled and weighed. The difference between the third and last weights equals the fixed carbon. The difference between the weight of the empty crucible and last weight equals the ash.

The ash determined by the above method is usually lower than the ash as determined by the method recommended in the "Report of the Committee on Coal Analysis." This difference is probably due to the complete removal of CO_2 from the ash by the above method, which in the coal was combined with calcium in the form of $CaCO_3$ or limestone. The method given in the report of the committee does not completely decompose the $CaCO_3$; hence the difference.

B.t.u. Determination

Another sample of 0.5 gram is taken from the bottle containing the 100-mesh sample. Should the moisture content of this sample be over 3.5 per cent., as determined by the proximate analysis, the weighed sample is placed on a watch glass and put in the oven where it is kept at 105 deg. C. for about half an hour; by this treatment the moisture will be reduced enough to allow the B.t.u. determination to be made. A Parr standard calorimeter is used, manipulation being made as given in the directions furnished with the instrument.

Sulphur in Coal

The residue is carefully removed from the bomb of the Parr calorimeter to a clean beaker covered with a watch glass. The bomb is carefully rinsed into the beaker with hot water from a wash bottle. The beaker is then covered with the watch glass and 30 c.c. of concentrated hydrochloric acid is slowly added, keeping the beaker well covered. After the reaction has ceased the solution should be acid. This solution is filtered to remove any foreign particles, and the residue is well washed with hot water until the filtrate amounts to about 200 c.c. The filtrate is heated to boiling, then keeping just below the boiling point, 10 c.c. of a 10 per cent. barium-chloride solution is added very slowly (taking 8 to 10 min.) with constant stirring, through a pipette or other device. After heating and stirring for 5 min. more, the solution is set aside. When barium sulphate has settled well the liquid is decanted through an Ashlers filter, the precipitate is washed several times with hot water by decantation, transferred to the filter and washed until the washings are free from chloride.

The moist filter is placed in a weighed crucible, the moisture driven off with a very small flame, charred slowly, then the heat increased until all carbon is removed. It is next cooled and weighed. The weight of barium sulphate multiplied by 2 (for 0.5 gram was taken) multiplied by 0.1373 equals the sulphur in 1 gram of coal.

For a more rapid method the Parr sulphur photometer may be used. The directions sent with the instrument are followed.

Analysis of Ash

Samples of ash are treated the same as coal, the ash is sampled and pulverized to pass a 100-mesh sieve.

Moisture, volatile matter, fixed carbon and ash are determined in the same manner as with coal. Care must be used, when working with ash, to burn out all the carbon present, there being so much mineral matter, traces of carbon may be left in the ash residue.

In making the B.t.u. determination on an ash, should the combustible matter be so low that the charge does not ignite, benzoic acid is used along with the ash to help the combustion.

Several blanks are run with benzoic acid alone, 0.25 gram being a good amount to use. Then a sample is run with the same weight of benzoic acid but with 0.25 or 0.5 gram of ash added. Then, subtracting the temperature rise due to the added benzoic acid from the total rise due to benzoic acid plus ash, the rise due to ash is obtained from which the heat value is calculated in the usual way.

Oil Testing

The methods of oil testing employed by two companies are described in the report, but as they closely follow standard methods, specific description is not given.

Several types of viscosimeters are in use, but comparable results cannot be got with them even when of the same make. This is not a serious defect, however, for what is wanted in any case is only a comparison between the delivered oil and the oil of the guaranteed grade. If it is desired to compare an oil furnished to another company with an oil being used in one's own service, the simple expedient is to secure a sample and run it on one's own viscosimeter.

In answering the questions sent out in regard to oils, many companies replied that the only tests made on oils were service tests. While it cannot be denied that service tests are perhaps the only tests that will select an oil suitable for the service, still, after having made the service tests and determined the characteristics of the oil in the laboratory, it is simple to check the deliveries from time to time and determine whether oil of the guaranteed quality is being received. It would thus be possible to reject an inferior oil before it had been used and possibly prevent thereby much damage to the machinery. The simple oil tests would do this.

Some companies use a friction-testing device, with which the lubricating quality of an oil can be determined. This apparatus is no doubt of value in testing oils for bearings, etc., and the conditions of service can be closely duplicated with it. The only test to determine the entire suitability of a cylinder oil, however, is to test it under actual working conditions in the cylinder.

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A number of representatives from engineering organizations in Boston and the vicinity met on Friday evening, Jan. 10, to consider the advisability of organizing a league for mutual protection against the aggression of the central station. W. K. Campbell was elected president pro tem. and Edward DeGruchy, secretary. Invitations will be extended to all organizations and individuals interested, and a permanent organization effected at an early date.

Annual Meeting of the Heating Engineers

On Jan. 21, 22 and 23 the American Society of Heating and Ventilating Engineers held its nineteenth annual meeting in the Engineering Societies Building, New York City. Some interesting papers and a number of committee reports which should prove valuable were presented. On Tuesday afternoon the first session was opened by acting President John F. Hale, who referred briefly to the conduct of the affairs of the society and immediately after read President Allen's address, which was written within hearing of the guns of the Balkan war. Prof. Allen realized that there was still much to be done even in the elementary development of the science of heating and ventilating and outlined some experimental work which might be profitably carried out by the society. Data on the heat losses in various forms of building construction used in this country, and particularly the newer forms of construction, such as hollow tile, hollow cement bricks, reinforced concrete, etc., would be of particular value. The proper temperature at which the air in a room should be maintained should be scientifically studied, and there is still much need for the development of a more comprehensive method of determining the amount of radiation necessary to heat a given building. The formulas at present do not include many factors which enter into the problem, and to check existing rules it will be necessary to have available, data obtained from actual installations in daily operation. The lack of such information at the present time is very noticeable. Even less is known about ventilation than heating and on this subject there is a great field for experimental work which must be done jointly by the engineer and the physiologist. What constitutes pure air? What are the safe limits of purity? At what temperature should air be used for ventilation? And many others are the questions which must be answered. The president recommended a closer relation between the society and the various laboratories throughout the country where this work might be carried on and an intimate association with the members of the medical profession and physiologists.

Routine business in the shape of reports by the secretary, treasurer, board of governors; Illinois, Massachusetts and New York Chapters and by various committees occupied the balance of the session. The secretary reported an increase in membership for the year of 24, making a total of 449.

The committee on tests consisting of three members reported individually. The investigations of L. C. Soule, chairman, had been limited to the relative efficiency of pipe coils and cast-iron radiation in fan blast heating. Given the same conditions the same amount of heat was transmitted with either kind of surface. The data obtained will be incorporated in a paper for the summer meeting.

James A. Donnelly gave a report of the trip which members of the New York and Boston chapters recently made to the testing laboratories of the H. B. Smith Co., Westfield, Mass., the Sheffield Scientific School of Yale and the International Y. M. C. A. gymnasium at Springfield. On Thursday he also submitted some suggestions on a standard method of testing radiator steam traps or return-line vacuum-system appliances.

The third member of the committee, Prof. L. A. Harding, outlined the work he had done on determining the loss of air pressure in ducts of 6, 9½ and 23 in. in diameter. The tests were conducted under commercial conditions and with velocities ranging from 1500 to 2500 ft. per min. Prof. Harding had also made investigations on heat transmission through building materials. The data had not been arranged for publication, but at a later date will be presented in these columns.

On Tuesday evening the election of the following officers was announced: President, John F. Hale; first vice-president, E. F. Capron; second vice-president, A. B. Franklin; treasurer, James A. Donnelly; board of managers, F. T. Chapman, Ralph Collamore, D. D. Kimball, W. W. Macon, J. M. Stannard, Theodore Weinshank. According to the constitution the two past presidents, Prof. J. R. Allen and R. P. Bolton, are also members of the board.

C. E. Beery read the first paper of the meeting on a system of downward ventilation employed in the Hall School of Rockford, Ill., which is built of brick with wood floor construction. The system consists in part of a series of pipe coils suspended 20 in. below the ceiling, where a maximum temperature of 85 deg. is maintained. Air for ventilation is warmed by vento stacks in the basement and enters the room at a temperature never above 73 to 74 deg., through a double diffuser, to break the current, just below the warm stratum of air at the ceiling. With an air vent in each corner at the floor, a downward air movement is produced at a velocity approximating 2 ft. per min. The rooms heated in this manner are remarkably free from air currents or drafts and up to date the system has given excellent satisfaction. The paper in fuller detail will be published in a later issue.

Frank Irving Cooper read a paper on "Improved Air Conditions in a Boston Residence." The installation consisted of electric radiators, which a low rate for current made feasible, humidifying and air-washing apparatus and a machine for supplying ozone in the amount desired. The electric heater was designed to heat 200 cu.ft. of air per min. from 0 to 70 deg. F. and was automatically controlled.

A committee report on schoolroom ventilation was then read by Mr. Cooper. It was supplemented by an extended report by Charles F. Eveleth on humidifying air at the Oliver Wendell Holmes School in Boston.

On Wednesday morning the session was opened with a paper on "The Design of Indirect Heating Systems with Respect to Maximum Economy and Operation," by Frank L. Busey and Willis H. Carrier. The object of the paper was to show that there is a definite relation between the cost of power and the cost of the apparatus, and to determine what ratio between these two factors will give the best results. The authors presented a number of interesting charts bearing on the subject and worked out some practical applications of the principles advanced.

In conclusion it was stated as regards the heater that the most economical point will be reached when the installation is so proportioned that the yearly cost of power due to the frictional resistance of the heater amounts to 28.6 per cent. of the annual interest and depreciation allowance on the first cost of the heater, this

being true regardless of variations in the depth of heater, temperature rise or steam pressure.

Through the piping or conduits the most economical velocity is such that the annual cost of power due to the piping resistance is one-third of the annual allowance for interest and depreciation. This allowance may be assumed to be about 25 per cent. on the original cost of the installation.

While the lower velocities and consequently lower resistance would require the use of larger fans to operate at high efficiency, considering the entire installation of heater, piping and fan, the annual cost of power should be practically 30 per cent. of the total annual allowance for interest and depreciation. If this allowance is taken at 20 per cent. as an average it would give 6 per cent. on the first cost as the most economical yearly rate to be allowed for power.

Dr. M. W. Franklin talked entertainingly on ozone and its application. He pointed out that ozone had been used with success as a deodorizer in tanneries, glue and fertilizing plants, tunnels and the like where any amount of ventilation would not obviate the nuisance in or outside of the plant. It was also of advantage as a supplement to ventilation in overcrowded factories where the usual amount of air per person is not available.

In the evening the annual banquet of the society was held at the Hotel Martinique, with the newly elected president, John F. Hale, presiding. Mrs. Florence Kelly, secretary of the National Consumers' League, made a plea for the wider dissemination of knowledge on heating and ventilation and for the appointment of intelligent factory inspectors. John Martin, of the Board of Education of New York City and chairman of the committee appointed some time ago to investigate the heating and ventilating of New York schools, spoke of the conditions existing in the city and the desirability of designing ventilating systems so that they might be supplemented by opening windows.

At the session on Thursday morning, Frank K. Chew, editor of the *Metal Worker, Plumber and Steam Fitter,* read an interesting paper on a combination warm-air and hot-water system for heating and ventilating a residence. The space to be heated amounts to 22,057 cu.ft. and the exposure to an equivalent of 1212 sq.ft. of glass surface. The furnace is of the hot-air type, with a hot-water drum having 5.5 sq.ft. of surface in the combustion chamber. Full details of the furnace and of the services in general are given in the paper.

Frank T. Chapman, chairman of the Committee on Ventilation of Motion Picture Theaters, was then given the floor to read his report item by item for discussion by the convention. The principal requirements were a minimum of 4⅓ sq.ft. of floor area as a seating space per occupant, a minimum of 80 cu.ft. of air per occupant and a temperature ranging between 62 and 70 deg. F. Specific directions were also given for machine-booth ventilation.

One of the topics for discussion brought up at the last session of the convention was a request for a standard method of using an anemometer in measuring air velocity in front of a register. A committee had been appointed, which reported as follows:

Divide the opening into eight equal rectangular areas with no side longer than 10 in. Where the opening is larger than the maximum obtainable with these figures, use twelve areas. Readings of one-half minute duration are to be taken at the center of each area. The average of the readings is to be taken as the average velocity. Any negative reading due to a dead space in the register is to be deducted. The average velocity times the net area of the opening will equal the volume of air discharged. When the anemometer is held 2 in. from the face of the register no allowance need be made for the iron or wire mesh, the full area of the opening being taken. With a diffuser the total area is to be that contained within the outer perimeter.

In the discussion it was brought out that the anemometer is not an accurate instrument for measuring air velocity in front of registers and should not be used. The pitot tube was better, but in the opinion of W. J. Baldwin, neither instrument permitted of any great accuracy in this work. He recommended the use of a cone-shaped hood and the measurement of the velocity at the apex as a more accurate method.

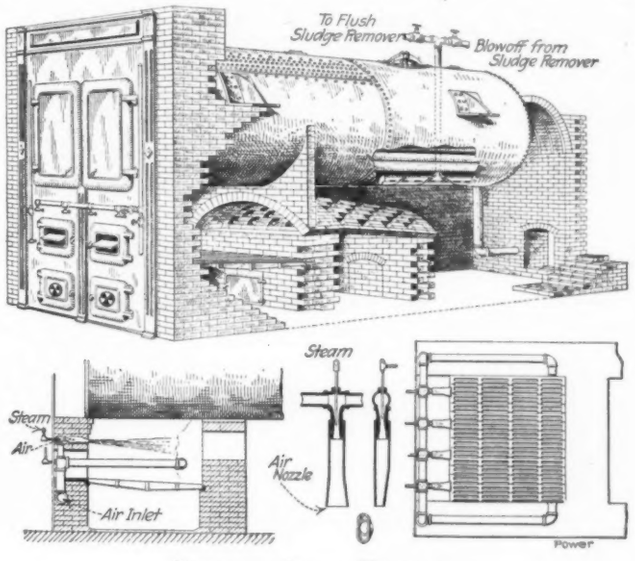
Other matters discussed at this session were Mr. Donnelly's method of testing radiators and a letter from the American Society of Mechanical Engineers requesting coöperation in an addition to be made to the present standard of flanged fittings. A committee was appointed to confer with the mechanical engineers.

Special entertainment was provided for the visiting ladies in the way of sight-seeing tours, automobile rides, luncheons, matinee parties and on Thursday evening opportunity for all was given to attend the Hippodrome.

Broman Oven Furnace

By R. Cederblom

Two furnaces similar to the one shown in the accompanying illustration were specified as part of a complete power plant installed by the writer in a wood-working



Broman Oven Furnace

factory about a year ago. The results obtained from this plant have been entirely satisfactory both in regard to smokelessness and efficiency.

Ordinarily when one or more brick arches are used to obtain smokeless combustion, they are installed with more

or less sacrifice of heating surface unless placed entirely outside of the boilers, which often is objectionable on account of space, loss of heat from radiation, etc. With the construction shown, practically the entire half of the shell is exposed to the flame and hot gases, as they pass through numerous small openings in the top of the arch and come in contact with the metal.

The mixture of air and unburnt gases passes over the bridge-wall, and into a combustion chamber with a solid back and an arch with a number of small perforations, 4x6 in., through which the gases must pass before coming in contact with the shell. It is quite natural that at the high temperature existing in the oven and the gases split up into small volumes in passing through the perforations in the hot brick arch, the combustion should be complete, providing sufficient air is present. It also stands to reason that with such thorough mixing of the air and gases a minimum quantity of air is required for complete combustion, and less heated, free air goes to waste up the chimney.

The combination steam and air nozzles introduced through the front and sides of the furnace are used to supply the extra amount of air required when a fresh charge of coal is thrown onto the grates and at the same time to thoroughly mix with air the gases driven off the fresh fuel before they enter the combustion chamber.

Previous to the writer's experience with this furnace, four of them were installed under 66-in. by 18-ft. boilers constituting part of the power plant of one of the large department stores in Chicago. Originally the boiler plant consisted of six 66-in. by 20-ft. and the four 18-ft. boilers equipped with ordinary grates and settings. During the cold season all of the exhaust steam was required for heating purposes with never less than seven boilers in operation. Shortly after the 18-ft. boilers had been equipped with the perforated arch furnaces, the central station secured the contract for supplying heat as well as power to this building, but not being in a position to supply the heat the first season, the four boilers were retained and readily furnished enough steam to heat the entire building.

The furnace is the invention of J. G. Broman, a mechanical engineer of Chicago, who has given considerable time and study to the subject of combustion.

Engineers' Entertainment at Atlantic City

Association No. 9, N. A. S. E., of Atlantic City, N. J., entertained its many friends at Turner Hall, in that city on the evening of Jan. 11. The national and state officers were assisted by a New York delegation of well known engineer entertainers, including Jack Armour, Joe McKenna, Billy Murray, W. S. Martell, W. S. Leonard, J. W. Greves, John Callahan, Edward Sears, Frank Martin and Frank Tuttle.

President Truman, of the local association, welcomed the visitors and friends. The toastmaster was State Deputy John Jenkinson, chairman of the entertainment committee. After the songs and stories, James R. Coe gave a brief talk on the work of the National Association of Stationary Engineers. Over 100 members and guests attended the banquet.

Boiler Explosion at Howland, Me.

From information received, two of the seven return-tubular boilers of the Howland Pulp & Paper Co., Howland, Maine, exploded at 8:30 a.m., Jan. 20, killing two men, injuring several others, and wrecking the boiler house.

Atlantic City N. A. S. E. Engineers' Banquet

Both men killed were firemen, and were found pinned beneath the wreckage, severely scalded by escaping steam and crushed by flying débris. Both were alive when taken from the wreckage, but one died three hours later and the other in five hours.

The explosion completely wrecked the boiler house and demolished the setting of the remaining five boilers. Two steel stacks were knocked down, one falling on the mill, doing additional damage. The pump house and engine room were wrecked, and flying live coals started several fires which were put out without difficulty.

It is reported that the boilers were 22 years old. They were insured by the Hartford Steam Boiler Insurance & Inspection Co., and were allowed to carry 80 lb. of steam. The loss is reported to be between $40,000 and $50,000.

Among those who escaped death, the most seriously in-

jured was a fireman, who received three broken ribs and numerous bruises, but is expected to recover.

One large part of the boiler crashed into the mill, adding considerable damage to that done by the falling stack.

Locomotive Boiler Explosion

The explosion of the boiler of a Detroit & Toledo Shore Line R. R. locomotive at Detroit, Mich., Jan. 5, caused the death of one man and the serious injury of six others. The engine was being prepared to haul a passenger train to Toledo when the explosion occurred. A later inspection of the crown sheet disclosed that the plate was buckled between the stays, or forced down from the internal pressure in many places 1/8 in. The effect of the buckling between the stays was to enlarge the threaded holes in the plate, thereby greatly lessening their holding strength. All stays in the crown sheet had been repeatedly hammered up or calked to prevent leakage. The heads which the stays no doubt had originally were almost entirely pounded away. The first thread on the end was apparently destroyed from the repeated hammering.

In addition to the defective stay threads, 41 stays were found to have been broken at some time preceding the accident. The collapse of the crown sheet would not have occurred from the broken stays, if the threads on the balance of the stays had been in good condition, because the broken stays were so located that the curvature of the furnace added much strength.

The boiler bore evidence of great neglect, of long standing, with stay-bolt ends and stays broken, try-cocks dirty and water gage-glass cock partly closed. An ordinary inspection should have disclosed to a competent inspector that this boiler was in an unsafe condition.

It is not evident that the water was low just preceding the accident, and the complete absence of scale on the crown-sheet after collapse does not warrant the belief that the crown sheet was hot just before the collapse, as any scale thereon would have been cracked off by the elongation of the plate after collapse. The scale on the crown-sheet under the crown bars was not in any way disturbed.

More Turbine Trouble on the "Lusitania"

According to press reports of Thursday, Jan. 23, the steamship "Lusitania" is again laid up in Liverpool for repairs to at least one low-pressure turbine. She arrived at that port Dec. 31.

As usual no official information is available concerning the trouble, but it is understood that this lay-up is due to the bursting of the turbine casing, which, it is said, damaged the ship's bottom. The "Lusitania" is indeed unfortunate with her turbines, or at least with a forward port turbine, which seems to be the one giving the most trouble. Early last June a forward port turbine, stuck fast shortly after leaving Liverpool and the vessel continued to New York at reduced speed. About the middle of last August the daily press reported that the same turbine, presumably, had a "hot box," which made so much noise that nearly all on board were wakened. Later, investigation developed that the passengers were wakened by the tearing to pieces of the turbine blades—quite different from a "hot box."

Last November a new port low-pressure turbine was installed, but no official information will confirm the report that this is the one that went to pieces during her late December voyage from New York.

Ohio Examiners' and Inspectors' Report

The report of the work done by the Ohio state examiners of steam engineers and the boiler-inspection departments during the fiscal year ending Nov. 15, 1912, shows:

Applications for engineer's license	2291
Applications for boiler operator's license	1410
Total	3701
Engineers failing to qualify	1149
Boiler operators failing to qualify	388
Total	1537
Engineers qualifying	1142
Boiler operators qualifying	1022
Total	2164
Engineers' licenses revoked	3
Engineers' licenses expired	690
Boiler operators' licenses expired	271
Total	964
Engineers' licenses renewed	12,775
Boiler operators' licenses renewed	1,822
Total	14,597
Engineers holding licenses	13,917
Boiler operators holding licenses	2,844
Total	16,761
Receipts from examination and renewals	$36,596.00
Maintenance expenses	29,557.23

There were 14 employers and 18 operators convicted of violations.

A census taken of the steam plants in the first, second and seventh districts, which include Cincinnati, Cleveland and Toledo, by the board of steam engineers' examiners, shows the benefit derived from convictions against violators, the increased number of licenses issued, and the consequent increased protection afforded the public.

The law creating the boiler-inspection department went into partial effect on Jan. 1, 1912, but did not become fully effective until July 1. The following report covers about seven months:

State inspections	1,980
Insurance inspections	11,670
Boilers registered and certified	12,150
Boilers held for repairs	302
Boilers condemned and out of service	198
"Ohio Standard" boilers built and approved since July 1	702
Boiler manufacturers registered and authorized to build "Ohio Standard" boilers	59
Applicants examined to qualify as boiler inspectors	170
Qualified	146

From the list of those who qualified, ten inspectors were commissioned to act as "general inspectors" in the state service and 104 as "special inspectors" in insurance service.

Three boiler explosions, in which three persons were killed and one injured, were reported. Four explosions, killing four persons and injuring 11, occurred on boilers not covered by law.

For a Museum of Industrial Arts

The value of museums as educational factors has been recognized by the foremost nations of all civilizations, but the great works of the engineer and mechanic built upon scientific research have thus far had but scant recognition.

Germany has erected the first comprehensive museum of the masterpieces of science and the technical arts at Munich. In less than five years its marvelous success encouraged the managers to invest the millions supplied by German industrialists in a permanent building on an island in the Isar, now nearing completion. Last April a commission of five, with as many engineer assistants, was sent to this country to look for more contributions of machines, models, drawings, etc., to enable it to add an American section to each of the main divisions and to encourage American engineers to begin a similar movement.

America owes its greatness to the courage and skill with which its artisans and engineers solved the gigantic problems which the conquest of a new continent imposed, and it is this generation which has profited by the labors of these pioneers and which should search out and preserve the records of their work.

Nearly thirty years ago, John E. Sweet, past president of the American Society of Mechanical Engineers, wrote: "May the time come when we shall have a museum in which there shall be gathered the finest specimens of workmanship with the masterpieces of our great engineers."

It is to be hoped that every man familiar with any one of the many industries will search out such relics as still exist in drawings, models, descriptions or specifications and,

once used but now outclassed or outworn tools, machines and structures which represent steps in industrial progress, rescue them from the oblivion of the scrap heap and notify the committee on museums of the American Society of Mechanical Engineers of their existence, condition and location, and explain to the present owners their educational and sentimental value. This knowledge of what is available for preservation must precede the planning of any building to house them and will largely aid in inducing cities, corporations, and individuals to proffer the financial aid necessary to build up some great national museum of the industrial arts. The movement once begun and its educational value made manifest, other museums will grow up in various communities illustrating special industries.

Dr. Kunz, who is also chairman of the plan and scope committee for the celebration of the century of peace between England and America, has proposed such an industrial museum as the fittest expression of American pride and joy in this achievement.

Dinner to C. A. Griscom, Jr.

The rapid growth during the past year of the Griscom-Russell Co., the successor to the Griscom-Spencer Co., Russell Engine Co. and the James Reilly Repair & Supply Co., was celebrated by a dinner given to President Clement A. Griscom, Jr., by the G-R Lunch Club, at the Garret Restaurant, New York City recently. It completed Mr. Griscom's first year in the active management of the business, and his twenty-first as president.

Nearly one hundred members of the staff attended, including the New York sales, engineering and accounting forces, and the cost and office staff and foremen from the Jersey City shops. The works at Massillon were represented by Arvine Wales and R. J. Pabodie, M. E., works manager. G. V. S. Michaelis, vice-president and treasurer, was toastmaster.

Educational Work of Beacon Association No. 30, N. A. S. E.

Herewith is presented Question Paper No. 5-B issued by the Educational Committee of Beacon Association No. 30, N. A. S. E., as illustrating the good work being done by operating engineers for their mutual improvement. The questions reflect the earnestness of the members of the association and are not only of technical interest, but should be appreciated by owners of power plants in evidence of the breadth of intelligence which engineers are called upon to exercise in the practice of their vocation.

The question paper is as follows:

1. How is the manhole plate made, and how put in, when a boiler has a circular manhole opening?
2. Describe a gusset stay. In what type of boiler is it used? Is there any objection to its use in a horizontal tubular boiler?
3. Why does the Board of Boiler Rules object to the use of a lead manhole gasket below the water line?
4. How is the underneath part of Heine boilers got at for inspection?
5. Why are the fire tubes of vertical boilers of smaller diameter than those of horizontal tubular boilers?
6. If the water line in a vertical boiler is located at a height of $\frac{2}{3}$ the length of the tubes, will the capacity of the boiler be increased, or decreased, if the water line is raised? Explain why.
7. Where is the circulating pipe attached to a vertical Cahall boiler and what is it for?
8. What is the thickness of the metal in B. & W. boiler tubes? Would there be anything gained, or lost, if the metal in these tubes was made twice as thick?
9. What part of the boiler has the greatest pressure on it? Why?
10. If a Massachusetts standard boiler, horizontal tubular type, has a manhole in the front head beneath the tubes, will both heads of that boiler beneath the tubes require bracing? Give the reasons for your answer.
11. What is gained by the use of an economizer? Where should it be located? What troubles are liable to arise through its use?
12. Why do injectors refuse to work when the feed water is too hot?
13. If one of the springs of a Waters governor should break while the engine was running, what would happen?
14. What horsepower will a man weighing 180 lb. develop in walking up a flight of stairs 100 ft. high in one minute?
15. What is meant by "The Range of the Governor?" Do all governors have the same range, if not, why not?
16. Why is the solid piston generally used in preference to the built up piston in high-speed engines?
17. Which do you consider the better connection for a piston rod in a crosshead, the screwed end with check nut, or the keyed tapered end? Why?
18. Why is the cutoff of a plain slide-valve engine limited to about $\frac{5}{8}$ stroke when some balanced slide-valve engines cut off much earlier in the stroke?
19. A Rice & Sargent engine has a sliding foot; what for?
20. Why should a Corliss engine use less steam per indicated horsepower than a slide-valve engine?
21. Draw an indicator card, such as would be taken from a Westinghouse compound engine and explain the same.

SOCIETY NOTES

The annual meeting of the American Institute of Consulting Engineers was held, Jan. 14, at the Engineers' Club, New York City. Henry Holgate, Montreal, Canada, and Daniel E. Moran and Charles Sooysmith, New York City, were elected members of council to serve three years. F. A. Molter, New York City, was elected a member of council to serve one year. After the routine business was transacted, Prof. George F. Swain, of Harvard University, addressed the meeting on the question of 'Education," which was very ably discussed by Rudolph Hering, Gen. T. A. Bingham, Prof. Gardner S. Williams, of Ann Arbor, Mich., and Frank J. Sprague.

The Interstate Oil Mill Superintendents' Association will hold its convention in Atlanta, June 4, 5 and 6, at the Auditorium Armory. The plans include the most comprehensive exhibit of oil-mill machinery and appliances ever held in the South and the main room of the auditorium has been reserved for the exhibits. Both operating and still exhibits will be shown and an attendance of 250 oil-mill superintendents is expected. J. C. Holmes, president of the Interstate Oil Mill Superintendents' Association, Shellman, Ga., will give information relative to the superintendents' meeting, and F. C. Myers, secretary of the Oil Mill Superintendents' Auxiliary, has complete information in regard to exhibit space and the exhibitors' association.

OBITUARY

LAVINIA MARSTON SWASEY

Mrs. Lavinia Marston Swasey, wife of Ambrose Swasey, president of the Warner & Swasey Co., Cleveland, Ohio died at her home, 7808 Euclid Ave., on Jan. 22. Mrs. Swasey was born at Hampton, N. H., July 28, 1842, the Marston family having been among the pioneer settlers of that community.

Mrs. Swasey had lived in Cleveland for more than thirty years and was well known in society, in benevolent work, and to members of the American Society of Mechanical Engineers and their wives, having frequently attended the meetings. She was also active in the Young Women's Christian Association, and was selected by its founders as one of the original Rose Fund trustees.

Wide experience of travel in many parts of the world had broadly extended Mrs. Swasey's sympathies in lines of missionary effort, and the hospitalities of that home, as well as the presence of its gracious mistress, will be missed by a large number of friends.

PERSONALS

F. D. Martin, consulting engineer, has been retained to prepare preliminary estimates for a municipal electric-light plant at Fort Scott, Kan.

Heinrich Homberger, consulting engineer, 864 Pacific Building, San Francisco, has been appointed advisory engineer for hydraulic-plant equipment by the Oro Electric Corporation in connection with the proposed 40,000-kv.-amp. power plant on the North Fork of the Feather River.